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An annotated bibliography on
Seed Storage and Deterioration

A review of 20th century literature reported in the English language

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AN ANNOTATED BIBLIOGRAPHY ON SEED STORAGE AND DETERIORATION

A Review of 20th Century Literature Reported in the English Language

By Edwin James[1]

Several excellent books have been printed that cite references on seed storage, physiology, and deterioration. Some of the literature, however, that is cited in these books was found not to be common to them all. Furthermore, it was found, when comparing the citations in these books with known literature, that many important papers had been omitted. Every piece of literature, therefore, that could be obtained regarding seed storage was investigated in compiling this bibliography, and the publications read by the writer.

In spite of diligent search there is yet a possibility that some papers have been overlooked. The books mentioned above, owing to their copyright dates, provided no citations later than 1955. It is not intended, however, that this bibliography be considered complete as a source of information concerning seed storage and deterioration, but rather as an indication of where various kinds of information might be found. An omission herein, therefore, is not meant to imply a lack of importance. Many bulletins of extension type or publications concerning bulk and farm storage that contain no research data were purposely omitted because the information in the numerous publications listed in the bibliography is applicable to these situations. The inclusion of many popular-type articles is for the purpose of the selection of original articles on the part of the reader.

For the sake of brevity the bulk of the experimental work for most articles is omitted; an abstract presents in general those conclusions that, in the opinion of the writer, contain the salient points of the article. Most of the articles reviewed contain valuable information not covered in the abstracts. The reader is referred to the original paper for further details.

For the convenience of the reader a subject matter index follows the bibliography. An attempt is made to make this index more useful through the use of cross references. In many instances the information indexed is not found in the abstract but, rather, in the original.

1. ANONYMOUS. Noble fir seed keep well in cold storage. U. S. Forest Serv., Forest Worker 4 (4): 14-15. 1928.

Seed of noble fir, Abies nobilis (=A. procera), with 58 percent viability was stored in sealed jars at 9° to 14° F.; after 4 years its germination was reduced to 21 percent and after 5 years to 13 percent. The germination at 4 years was superior to that at the end of 1 year of conventional storage.

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2. ANONYMOUS. Seeds undrowned after 23 years under water. Sci. News Letter 24: 131. 1933.

Some seeds of Abutilon theophrasti were viable after 23 years' storage under water.

3. ACUÑA, R. A. The effect of storage on the germination of West Indian cedar. Philippine Jour. Forestry 1: 293-299. 1938.

When sealed in bottles, seeds of West Indian cedar (Cedrela mexicana M. Roem.) dropped regularly in germination to a complete loss of viability in 147 days. Storage temperatures and seed moisture contents are not given.

4. ADAMS, A. B. A note on the longevity of "hard" sub-clover seed. West. Austral. Dept. Agr. Jour. (ser. 2) 20: 155. 1943.

Subterranean clover germinated 8.7 percent after being in contact with superphosphate for 14 years; checks had 11.0 percent germination.

5. AHLGREN, G. H., FISKE, J. G., and DOTZENKO, A. Viability of bromegrass seed as affected by dehulling and by storage in fertilizer. Agron. Jour. 42: 336-337. 1950.

Seeds of bromegrass were stored over a 15-month period, when seeds in 5-10-5 had lost their viability; those in 10-10-10 had 7 percent germination; and those in 18 percent superphosphate had 27 percent--as compared with the initial viabilities of 91 or 93 percent and the check germination, after 15 months, of 22 percent.

6. AKAMINE, E. K. The effect of temperature and humidity on viability of stored seeds in Hawaii. Hawaii Agr. Expt. Sta. Bul. 90, 23 pp. 1943.

Seeds of soybeans, lettuce, and alfalfa deteriorated rapidly under high humidity and temperature. Alfalfa dropped very little in germination at 71° to 80° F. and 15 to 45 percent relative humidity.

7. AKAMINE, E. K. Viability of Hawaiian forest tree seeds in storage at various temperatures and relative humidities. Pacific Sci. 5: 36-46. 1951.

Under the best storage conditions seeds of paper bark, brush box, turpentine tree maintained high viability for 4 years and mamani seed for 3 years. Norfolk pine, Monterey cypress, and Indian sandalwood dropped rapidly in germination under all storage conditions. In the test 59° F. and 45 percent relative humidity were best for paper bark and turpentine tree, 45° and 59° for brush box and Indian sandalwood. Open storage was more suitable for mamani and Monterey cypress at temperatures of 59° and 45° , respectively.

8. ALBERTS, H. W. Moisture content of corn in relation to relative humidity and temperature of the atmosphere. Amer. Soc. Agron. Jour. 18: 1029-1034. 1926.

Moisture content of corn was determined at temperatures of 30° , 20° , and 10° C. and at relative humidities between 10 and 90 percent. Little effect of temperature on moisture absorption was found.

9. ALBERTS, H. W. A method for storing small quantities of seed corn. Amer. Soc. Agron. Jour. 19: 567-568. 1927.

Temporary storage with layers of oats was effective in reducing the moisture of ear corn and diminishing fluctuations due to atmospheric changes.

10. ALLEN, G. S. Storage behavior of conifer seeds in sealed containers held at 0° F., 32° F., and room temperature. Jour. Forestry 55: 278-281. 1957.

In studies on 27 seed lots of 11 species of pines, seed of Douglas-fir was shown to maintain slightly better viability when stored at 0° F. than at 32°. In the other species 32° storage was as good as 0°. When stored at room temperature only six lots had viable seed at the end of a 7-year period. Longevity was associated with high initial germination.

11. ALTSCHUL, A. M. The storage of cottonseed. III. Factors affecting the storage of moist cottonseed. Oil Mill Gazetteer 49: 8-9, 11, 13. 1944.

Amino nitrogen in moist cottonseed increased from 3.5 milligrams at 10.5 percent moisture to 12.6 milligrams at 17.0 percent moisture. Free fatty acids for respective moistures were 1.3 and 8.2 percent.

12. ALTSCHUL, A. M. Chemical treatments of seeds to prevent heating and deterioration during storage. Cotton Gin and Oil Mill Press 50 (1): A2-A10. 1949.

A popular-type discussion of work on cottonseed at the Southern Utilization Laboratory. For details see reference numbers 109, 249, 250, 287, 288.

13. ANDERSON, J. A., and ALCOCK, A. W. Storage of cereal grains and their products. Amer. Assoc. Cereal Chem., Monograph Series Vol. 2, 515 pp. St. Paul, Minn. 1954.

Contributions by various authorities on moisture, storage, respiration, microflora, pests, drying, and country storage of grains.

14. ANDERSON, J. A., BABBITT, J. D., and MEREDITH, W. O. S. The effect of temperature differential on the moisture content of stored wheat. Canad. Jour. Res., Sect. C, Bot. Sci., 21: 297-306. 1943.

In a bin with 0° C. at one end and 35° at the other it was found that at the cold end the moisture content of wheat increased but at the warm end it decreased. With an initial moisture content of 14.6 the moisture content in the cold end rose to 20.0 percent in 316 days.

15. ARNDT, C. H. The internal infection of cotton seed and the loss of viability in storage. Phytopathology 36: 30-37. 1946.

Fungus infection was discounted as a primary cause of deterioration of cottonseed with 14.0 percent or less moisture at ordinary storage temperatures. Over a 28-month period the best storage condition was a temperature of 1° C. with seed at 12.0 percent moisture.

16. ASSOCIATED SEED GROWERS, INC. The preservation of viability and vigor in vegetable seed. Asgrow Monograph No. 2, 32 pp. New Haven. 1954.

Seeds of cucumber, onion, tomato, and pepper maintained a high degree of viability for 3 years when hermetically sealed and stored at temperatures of 60°, 70°, and 80° F.

Moisture contents of 8.0 to 8.3 percent were injurious to cucumbers. Ninety-degree temperatures were deleterious when onions were stored with 7.3 percent moisture, pepper with 5.3 to 6.7 percent, and tomato with 7.6 to 9.6 percent. Onions with 1.2 percent moisture held up well at room temperature for 9 years.

17. AVERY, A. G., and BLAKESLEE, A. F. Visible mutations from aged seeds. Amer. Nat. 70: 36-37. 1936.

Mutations were observed in 11 of 315 datura plants grown from seed 7 to 10 years old. In the 315 plants, 30 plants, or 9.5 percent, had pollen abortions.

18. AVERY, A. G., and BLAKESLEE, A. F. Mutation rate in Datura seed which had been buried 39 years. (Abstract) Genetics 28: [69]-70. 1943.

Very few mutations were found in 358 seedlings grown from seed which had been buried 39 years. Three plants, or 5.1 percent, showed up with mutations in the F_2 generation, a much lower rate than for seed stored under laboratory conditions.

19. BABBITT, J. D. The thermal properties of wheat in bulk. Canad. Jour. Res., Sect. F, Technol., 23: 388-401. 1945.

In large storage bins the external temperature of the air had little effect on temperature of grain below 24 feet in depth.

20. BABBITT, J. D. Observations on the adsorption of water vapor by wheat. Canad. Jour. Res., Sect. F, Technol., 27: 55-72. 1949.

Movement of moisture through wheat was governed by diffusion of water through grain interstices rather than through the grain itself.

21. BAILEY, C. H. The handling and storage of spring wheat. Amer. Soc. Agron. Jour. 9: 275-281. 1917.

Respiration was found to be the cause of wheat heating. Increased respiration was attributed to increased moisture, which lead to the formation of gels (permitting easy diffusion). Heating was negligible when grain had less than 14.5 percent moisture.

22. BAILEY, C. H. Respiration of shelled corn. Minn. Agr. Expt. Sta. Tech. Bul. 3, 44 pp. 1921.

Respiration of shelled corn with the same moisture contents approximately doubled with an increase in temperature from 27.8° to 37.8° C. The corn was found to have 14.3 percent moisture at 25° and 75 percent relative humidity.

23. BAILEY, C. H. Respiration of cereal grains and flaxseed. Plant Physiol. 15: 257-274. 1940.

Oats and rye had a lower respiration rate than barley, rice, and sorghum, and corn a higher rate than the small grains. Flax had the highest respiration rate.

24. BAILEY, C. H., and GURJAR, A. M. Respiration of stored wheat. Jour. Agr. Res. 12: 685-713. 1918.

Heating of grain was attributed to biological oxidation of dextrose and similar sugars, mainly in the embryo. Respiration increased to a maximum at 55° C., but enzymes were largely inactivated at 65°.

25. BAKER, D., NEUSTADT, M. H., and ZELENY, L. Application of the fat acidity test as an index of grain deterioration. Cereal Chem. 34: 226-233. 1957.

A definite relationship was found between moisture content of grain and damage as related to fat acidity. Wheat and barley showed an increase of 1.0 to 1.5 percent in fat acidity for each 1-percent increase in moisture.

26. BAKKE, A. L., and NOECKER, N. L. The relation of moisture to respiration and heating in stored oats. Iowa Agr. Expt. Sta. Res. Bul. 165, pp. [317]-336. 1933.

A rise in oxygen consumption of oats coincided with increased moisture. Grain with 24 percent moisture attained a temperature of 47° C.

27. BARNER, H., and DALSKOV, F. Notes on the storage of Douglas-fir seed. Internatl. Seed Testing Assoc. Proc. 20: 57-61. 1955.

Seed of Douglas-fir that had been dewinged by hand and stored sealed at 4° C. showed no loss of viability in 4 years. Losses in germination were found to occur in the following decreasing order: (1) Machine dewinged seeds stored at 4°, (2) hand dewinged stored in a cellar at 8° to 15°, and (3) machine dewinged stored as in (2).

28. BARROW, E. H. R. The heating of cottonseed--its causes and prevention. Jour. Indus. and Engin. Chem. 7: 709-712. 1915.

Treating cottonseed with 5 percent calcium chloride, by weight, minimized heating and deterioration during storage.

29. BARTON, L. V. Effects of storage on the vitality of delphinium seeds. Boyce Thompson Inst. Contrib. 4: 141-153. 1932.

Very little loss was found in the viability of delphinium seeds at the end of a 62-month period when they were stored in sealed containers at temperatures of 8° and -15° C.

30. BARTON, L. V. Germination and storage of delphinium seed. Amer. Delphinium Soc. Bul. 2: 12-14. 1933.

After 39 months of storage in sealed containers at room temperatures, germination dropped to 7.4, 52.6, and 81.9 of the original germination of 1924, 1925, and 1926 seed, respectively. Open storage was superior at 5° F. to open storage at 46°.

31. BARTON, L. V. Storage of vegetable seeds. Boyce Thompson Inst. Contrib. 7: 323-332. 1935.

Seeds of several vegetable crops were stored at room temperatures and -5° C. for 3 years. Seeds were conditioned to different moisture contents by drying with CaO. Eggplant and tomato seeds kept well under all test conditions. Carrot, lettuce, and onion seeds required drying to one-third to one-half of their original moisture content to permit satisfactory storage at room temperatures; drying was not necessary for storage at -5°.

32. BARTON, L. V. Storage of some coniferous seeds. Boyce Thompson Inst. Contrib. 7: 379-404. 1935.

Seeds of *Pinus taeda*, *P. caribaea*, *P. echinata*, *P. resinosa*, *P. palustris*, *P. ponderosa*; *Picea abies*, (*P. excelsa*) and *P. canadensis* were stored at room temperatures and at 5°, -5°, and -15° C. for 6 to 7 years. When in sealed containers seeds stored at 5° or below maintained their viability. Storage under vacuum was also effective in prolonging viability. Seeds stored unsealed at room temperatures were completely deteriorated in a year.

33. BARTON, L. V. A further report on the storage of vegetable seeds. Boyce Thompson Inst. Contrib. 10: 205-220. 1939.

When dried over CaO and sealed, carrot, lettuce, tomato, onion, and eggplant seeds dropped only slightly in viability when stored 6 years. Carrot, tomato, and eggplant seeds kept satisfactorily when air-dried and sealed. Lettuce and onion seeds deteriorated rapidly when stored air-dry, either sealed or unsealed. Longevity of pepper seeds was short under all test conditions.

34. BARTON, L. V. Storage of elm seeds. Boyce Thompson Inst. Contrib. 10: 221-233. 1939.

Seeds with 7 percent and 8 percent moisture were sealed with air, with oxygen, and under vacuum, and stored 10 months. Oxygen was deleterious to viability except for storage at 5° and -5° C. Vacuum storage was superior with all temperatures.

35. BARTON, L. V. Storage of some flower seeds. Boyce Thompson Inst. Contrib. 10: 399-427. 1939.

Various flower seeds with moisture contents of 3.5 to 10.9 percent were stored at room temperatures and at 5° and -5° C. The lowest temperature was superior at all moisture levels in maintaining viability. At 5° high moisture resulted in the same amount of deterioration as room temperatures with low moisture. Keeping qualities of seeds were not dependent on initial germination.

36. BARTON, L. V. Relation of certain air temperatures and humidities to viability of seeds. Boyce Thompson Inst. Contrib. 12: 85-102. 1941.

Moisture absorption was lower with high temperatures than with low. Germination of tomato, flax, and peanut seeds stored at 20° to 30° C. remained high for 150 days at relative humidities of 35 and 55 percent, whereas germination of lettuce, onion, and long-leaved pine seeds was less, especially at the higher humidity and/or temperature. Decline in viability of all the varieties of seeds was great at 76 percent humidity with increases in temperature above 5° to 20°.

37. BARTON, L. V. Effect of moisture fluctuations on the viability of seeds in storage. Boyce Thompson Inst. Contrib. 13: 35-45. 1943.

Onion seed lost viability rapidly at humidities of 55 and 70 percent, whereas it remained high at 35 percent. Humidities fluctuating at intervals from 35 to 55 percent, 35 to 76 percent, and 55 to 76 percent were injurious, the last being most injurious.

38. BARTON, L. V. The storage of citrus seeds. Boyce Thompson Inst. Contrib. 13: 47-55. 1943.

Grapefruit seed with a low moisture content lost little viability in 16 weeks at room temperatures when in sealed containers. The best test condition was 5° C. with low moisture seed. Minus 5° was injurious.

39. BARTON, L. V. Viability of seeds of Fraxinus after storage. Boyce Thompson Inst. Contrib. 13: 427-432. 1945.

Open storage was ineffective in the preservation of Fraxinus seeds. Germination of F. pennsylvanica seed remained high for 7 years when stored at 5° C. with 7.6 percent moisture in sealed containers. With the same temperature but with 10.8 percent moisture, seed of F. excelsior began to deteriorate rapidly after 5 years of storage.

40. BARTON, L. V. Storage and germination of delphinium seeds. Amer. Delphinium Soc., Delphinium 1946: 27-30. 1946.

Seed stored either sealed or unsealed at room temperatures were practically worthless after 2 years. Decline was gradual at 5° C., but the seeds were unimpaired after 221 months' storage in sealed containers at 5°.

41. BARTON, L. V. Storage of seeds of the regal lily. North Amer. Lily Soc., Lily Yearbook 1947-48: 51-53. 1948.

Germination in 15 years dropped only slightly when lily seeds were sealed with 9.9 percent moisture and stored at -5° C; full viability was held when the moisture was reduced to 4.5 percent.

42. BARTON, L. V. Seed packets and onion seed viability. Boyce Thompson Inst. Contrib. 15: 341-352. 1949.

Foil-wrap, metalam, and vinyl-laminated aluminum foil were found to be effective moisture barriers at 76 percent relative humidity.

43. BARTON, L. V. Seed storage and viability. Boyce Thompson Inst. Contrib. 17: 87-103. 1953.

At -4° C. with low moisture contents carrot, eggplant, lettuce, onion, pepper, and tomato seeds maintained high viability for 20 years. Similar results were obtained with aster and verbena seeds at 16 years, and with gladiolus seed at 12 years. The years of satisfactory storage at -4° for other species were: Ulmus americana, 12; Pinus echinata, 16; P. taeda, 12; Lilium regale, 15; delphinium, 19.

44. BARTON, L. V. Effect of subfreezing temperatures on viability of conifer seeds in storage. Boyce Thompson Inst. Contrib. 18: 21-24. 1954.

Seeds of Douglas-fir, Sitka spruce, western redcedar, ponderosa pine, and western hemlock kept better for 3 years at -18° C. than at -11° or -4°. Marked deterioration at -4° was noted for all seeds except ponderosa pine.

45. BARTON, L. V. Storage and packeting of seeds of Douglas fir and Western hemlock. Boyce Thompson Inst. Contrib. 18: 25-37. 1954.

With moisture contents of 5.8 and 13.6 percent, Douglas-fir and western hemlock seeds retained full viability for 3 years when stored at -18° C. Sealed containers were better for storing low-moisture seed, but pervious containers were better for high-moisture seed.

46. BARTON, L. V. Storage of seeds of Lobelia cardinalis. Boyce Thompson Inst. Contrib. 20: 395-401. 1960.

At laboratory temperatures seed of lobelia stored with 6.9 percent moisture dropped from 73 to 52 percent viability when sealed in air for 1 year, but in open storage the drop was to 38 percent. Sealing in partial vacuum, CO_2, or N extended the laboratory storage life to 6 or 8 years; sealing in air was less effective, and oxygen was definitely deleterious. When stored open under humid conditions, seed at 5° C. had about the same longevity as that stored open in the laboratory; seed at -5° lasted 12 to 16 years. At both 5° and -5° , germination for the sealed storages was still moderately high at 25 years. Reduction of the moisture to 4.7 percent was noteworthy in that it extended under all conditions the germination capacity of laboratory stored seed.

47. BARTON, L. V. Life-span of frost-damaged corn seeds. Boyce Thompson Inst. Contrib. 20: 403-408. 1960.

Frost-damaged corn was maintained at full vigor for 9 years when stored at -5° C. in sealed containers and with moisture contents from 5.3 to 12.8 percent. At 30° storage in open containers the germination remained high for 6 years; at this temperature in sealed containers a full crop was encountered after the first year, but at the end of the following 2 years complete loss of viability had occurred.

48. BARTON, L. V., and GARMAN, H. R. Effect of age and storage condition of seeds on the yields of certain plants. Boyce Thompson Inst. Contrib. 14: 243-255. 1946.

Yields from seeds of aster, pepper, tomato, and lettuce stored for 7 months, 9 years, and 13 years at -5° C. were equal to those from fresh seed. Lettuce seed 13 years old produced larger heads than fresh seed did. Tomato seed stored for 13 years at room temperature produced inferior plants.

49. BASS, L. N. Packaging and storage of Kentucky bluegrass and creeping red fescue seed. Assoc. Off. Seed Anal. Proc. (1959) 49(1): 173-181. 1960.

Kentucky bluegrass and creeping red fescue seed were stored in tin cans, 10-mil polyethylene bags, and cloth bags under the following conditions: 33° F. and 80 percent relative humidity; 50° and 80 percent relative humidity; 70° and 20 to 40 percent relative humidity; 90° and 4 to 6 percent relative humidity; and at fluctuating room temperatures. Polyethylene bags were superior in maintaining of viability at high moistures (8.7 percent for Kentucky bluegrass and 11.4 percent for fescue) and at high temperatures. Storage in tin cans was otherwise superior to polyethylene or cloth bags.

50. BATES, C. G. One-year storage of white pine seed. Jour. Forestry 28: 571-572. 1930.

Germination results with 1-year storage of white pine seeds were best when the seeds were sealed at 30 percent relative humidity and kept in temperatures between 30° and 63° F. Relative humidity of 40 percent appeared too high for storage. The most rapid deterioration resulted with unsealed seed stored in a warehouse with temperature variations from 10° to 100°.

51. BATTLE, W. R. Effect of scarification on longevity of alfalfa seed. Amer. Soc. Agron. Jour. 40: 758-759. 1948.

Alfalfa seed after 14 years of storage had the following numbers of hard seeds per 500 for the various prestorage treatments: Scarification with H_2SO_4, 1; scarification with sandpaper, 0; heated to 60° C. for 7 hours, 0; and control, 5. For these various treatments germinations following storage were respectively, 0, 0.8, 17.2, and 23.0 percent.

52. BAYLIS, G. T. S. Viability of dusted wheat after storage. New Zeal. Jour. Sci. and Technol., Sect. A, 23: 126-130. 1941.

Treatments with Agrosan G and Ceresan U. T. 1875A improved the germination of wheat in storage for a year. Both dusted and undusted wheat with 16.7 percent moisture were injured when stored in a tight bin.

53. BEATTIE, J. H. Peanut seed may be kept for several years under proper conditions. U. S. Dept. Agr. Yearbook 1931: 426-427. 1931.

No material drop in germination resulted when peanuts were stored for 3 years at temperatures of 32°, 40°, and 72°F. Unshelled seed kept better than shelled.

54. BEATTIE, J. H., and BOSWELL, V. R. Longevity of onion seed in relation to storage conditions. U. S. Dept. Agr. Cir. 512, 23 pp. 1939.

For storage periods up to 4 years a temperature of 40° F. was satisfactory, but for longer periods of storage 20° was better. Moisture contents below 8 percent favored longevity.

55. BEATTIE, J. H., and TATMAN, E. C. Long-term storage of parsnip seed. Amer. Soc. Hort. Sci. Proc. 55: 435-437. 1950.

Over a 6-year period parsnip seed was preserved best with 4 percent moisture at a storage temperature of 20° F., followed by seed which was oven dry and stored at 40°.

56. BECKEL, A. C., and CARTTER, J. L. The effect of variety and environment on the equilibrium moisture content of soybeans. Cereal Chem. 20: 362-368. 1943.

Moisture equilibria of soybeans were found to be 4.97 percent at 18 percent relative humidity and to rise to 8.77 with increase in humidity to 60 percent, but to drop to 3.97 percent when humidity was again adjusted to 18 percent. Fifteen days was required for equilibria in humidity ranges from 18 to 60 percent.

57. BERTRAND, H. W. R. The storage of rice in steel drums. Trop. Agr. [Ceylon] 97: 188-189. 1941.

This article is of a general nature with no experimental data. Weevils were found to be dead after 9 months of storage.

58. BLACK, M. A. Effect of Ceresan on the germination of stored linen-flax seed. New Zeal. Jour. Sci. and Technol., Sect. A, 28: 217-218. 1946.

Full viability of flaxseed was maintained when it was stored at 50 percent relative humidity and 55° to 75° F. temperature. No injury resulted when seeds were treated with Ceresan and stored 33 months.

59. BLACK, R. H. Cause and prevention of "sick wheat." Milling Production 14: 11-12. 1949.

This is a popular article defining "sick wheat" as dead wheat and emphasizing the importance of reducing the moisture of wheat to 14 percent or less before storage.

60. BLAKESLEE, A. F. The aging of seeds and mutation rates. N. Y. Acad. Sci. Ann. 57: 488-499. 1954.

In plants from 9- to 10-year datura seed 7.0 percent mutations were observed, compared with 0.4 percent found in plants from year-old seed.

61. BLAKESLEE, A. F., and AVERY, A. G. (Abstract) Visible genes from aged seeds. Amer. Nat. 68: 466. 1934.

Attention was called to the relationship between age of seed and frequency of mutations. Five seed-flat mutations were observed from 350 second-generation datura plants.

62. BLAKESLEE, A. F., AVERY, A. G., BERGNER, A. D., and SATINA, S. Datura studies. Carnegie Inst. Wash. Year Book (1941-42) 41: 176-180. 1942.

Article covers work done on mutations in datura seed. A high mutation rate was associated with seed aged at room temperature, but the rate was extremely low in plants grown from seed buried 39 years. It was concluded that age alone is not responsible for increases in mutations.

63. [THE BODGER SEEDS, LTD.] Some interesting statistics on the longevity of flower seeds. Seed World 31 (11): 17. 1932.

Seeds of 126 flower species tested for longevity showed a variation of 1 to 6 years of life. Storage conditions are not given.

64. BOSWELL, V. R., TOOLE, E. H., TOOLE, V. K., and FISHER, D. F. A study of rapid deterioration of vegetable seeds and methods for its prevention. U. S. Dept. Agr. Tech. Bul. 708, 48 pp. 1940. (Condensed and preliminary report, Amer. Soc. Hort. Sci. Proc. (1938) 36: 655-659. 1939.)

At 80° F., and 75 to 80 percent relative humidity lima bean, kidney bean, sweet corn, peanut, cabbage, carrot, onion, spinach, and tomato seeds showed evidence of deterioration in 11 days, and definite injury was found in seeds of beans, cabbage, and carrots in 40 days. Sweet corn, onion, and spinach seeds were practically worthless after storage for 60 days. Beets stored well for 110 days. Moisture equilibria for seeds studied are given.

65. BOTTOMLEY, R. A., CHRISTENSEN, C. M., and GEDDES, W. F. Grain storage studies IX. The influence of various temperatures, humidities, and oxygen concentrations on mold growth and biochemical changes in stored yellow corn. Cereal Chem. 27: 271-296. 1950.

Under high temperatures and humidities total water soluble nitrogen and reducing sugars increased, whereas nonreducing sugars, total carbohydrates, and viability decreased. Changes in nonreducing sugars were considered the best index of deterioration. Mold counts increased logarithmically as humidities were increased from 75 to 100 percent.

66. BOTTOMLEY, R. A., CHRISTENSEN, C. M., and GEDDES, W. F. Grain Storage studies. X. The influence of aeration, time and moisture content on fat acidity, nonreducing sugars, and mold flora of stored yellow corn. Cereal Chem. 29: 53-64. 1952.

Both aerated and sealed corn was stored at humidities from 80 to 100 percent. An increase in free fatty acids, a decrease in nonreducing sugars, and a drop in viability were found to be associated with high moisture content. Under sealed conditions little change in fat acidity was found. Mold increases appeared to be associated with decrease in nonreducing sugars.

67. BRAND, C. J., and SHERMAN, W. A. Behavior of seed cotton in farm storage. In U. S. Dept. Agr. Bur. Plant Indus., Cir. 123, pp. 11-20. 1913.

With an initial germination of 53.5 percent, only 9 percent germination was obtained in a 47-day test when storage temperatures reached 111° F. Complete loss of viability resulted at a temperature of 135°.

68. BREESE, M. H. Hysteresis in the hygroscopic equilibria of rough rice at 25° C. Cereal Chem. 32: 481-487. 1955.

In humidity ranges from 10 to 90 percent about 60 days were required for equilibria to be attained by either absorption or desorption. Desorption equilibria were slightly higher than absorption equilibria at the end of a 60-day period.

69. BRENCHLEY, W. E. Buried weed seeds. Jour. Agr. Sci. [England] 9: 1-31. 1918.

Viable weed seeds were found in soils which had never been broken, and in soils which had been underneath grass for 300 years.

70. BRETT, C. C., and DILLON WESTON, W. A. R. Seed disinfection. IV. Loss of vitality during storage of grain treated with organo-mercury seed disinfectants. Jour. Agr. Sci. [England] 31: [500]-517. 1941.

Grains treated with mercurial fungicides at the rate of 2 ounces per bushel were not injured when stored for 12 months; but at the end of 24 months the speed of germination was reduced. With a treatment of 3 ounces per bushel, a greater reduction occurred. Wheat was affected the most by adverse storage conditions followed by oats, then barley.

71. BREWER, H. E., and BUTT, J. L. Hygroscopic equilibrium and viability of naturally and artificially dried blue lupine seeds. Plant Physiol. 25: 245-268. 1950.

Eight weeks were required to reach moisture equilibria at either high or low relative humidities, but only 3 weeks were required at 65 percent. Intermediate humidities were found to be better for storage of lupines than either very high or very low humidities.

72. BRISON, F. R. Influence of storage conditions upon the germination of onion seed. Tex. Acad. Sci. Proc. and Trans. (1941) 25: 69-71. 1942.

When onion seed was sealed either with air or under vacuum, no deterioration was found at storage temperatures of 34° to 40° F. for 62 months. Seed with 93 percent germination sealed with air and stored at temperatures of 40° to 95° had 70.4 percent viability at the end of 62 months; under vacuum the germination was 85.2 percent.

73. BRISON, F. R. The influence of storage conditions upon the germination of onion seed. Amer. Soc. Hort. Sci. Proc. 40: 501-503. 1942.

Storage of onion seed in cellophane bags was satisfactory for 3 years. When stored in cloth bags, seed was short lived at room temperature, but fairly long lived in cold storage. No deterioration was found after 3 years with storage under vacuum.

74. BROCKINGTON, S. F., DORIN, H. C., and HOWERTON, H. K. Hygroscopic equilibria of whole kernel corn. Cereal Chem. 26: 166-173. 1949.

At 75 percent relative humidity and 80° F. corn had a moisture content of 14.7 percent.

75. BROWN, E. Preserving the viability of Bermuda onion seed. Science 89: 292-293. 1939.

With an initial germination of 94 percent and a moisture content of 6.4 percent, onion seed when sealed and stored at room temperatures had 90 percent viability at the end of 13 years. When stored at 5° to 10° C. the germination was 89 percent.

76. BROWN, E., STANTON, T. R., WIEBE, G. A., and MARTIN, J. H. Dormancy and the effect of storage on oats, barley, and sorghum. U. S. Dept. Agr. Tech. Bul. 953, 30 pp. 1948.

Oats and barley stored at 36° F. under high humidity remained dormant for 36 months, but after ripening took place in 1 to 6 months when they were stored at 104°. Dormancy was not found to be general in sorghum.

77. BRUNSON, A. M. The effect of storage conditions on the longevity of seed corn. Purdue Univ. Agr. Expt. Sta. Ann. Rpt. (1948-49) 62: 42. [1949.]

When corn was stored with 11 percent moisture at 32° F. or below, viability at the end of 10 years was almost as high as at time of harvest. Differences in longevity among inbred lines were found.

78. BURGESS, J. L. Relation of varying degrees of heat to the viability of seeds. Amer. Soc. Agron. Jour. 11: 118-120. 1919.

Soybeans were able to withstand temperatures of 200° F. for 5 hours. Corn was reduced to 32 percent of its germination power when heated to 174° for 3 hours. Wheat heated to 230° for 3 hours lost 40 percent of its germinating power. Rye was only slightly affected when subjected to 212° for 5 hours.

79. BURLISON, W. L., VAN DOREN, C. A., and HACKLEMAN, J. C. Eleven years of soybean investigations. Varieties, seeding, storage. Ill. Agr. Expt. Sta. Bul. 462, pp. [121]-167. 1940.

When stored in metal cans soybeans dropped only 2 percent in germination the first year. Over an 8-year period the germination percentages were 58, 46, 33, 17, 8, 5, and 1. The germination of Illsoy at 7 years was comparable to Manchu at 4 years and Lexington at 5 years.

80. BURNS, R. E., WEIMER, J. L., and HENSON, P. R. Factors affecting the longevity of blue lupine seed. U. S. Dept. Agr. Agr. Res. Serv., ARS 34-5, 5 pp. 1958.

In 3 months lupine seed with 14.5 percent moisture dropped in viability when stored at 86° F., and in 6 months when at 68° or 74°. No deterioration occurred in 2 years in seed with 13.5 percent moisture. Maximum moisture of 12 percent is recommended for safe storage.

81. CAMERON, M. P. The effectiveness of organic compounds in controlling mold growth in grain. 1945. [Unpublished master's thesis, Univ. Saskatchewan.] (Original not seen.)

Diacetyl, phenothiazine, and 8-hydroxyquinone were found to be effective in controlling mold growth with no toxic effects on the embryo.

82. CARRUTHERS, W. On the vitality of farm seeds. Roy. Agr. Soc. England Jour. 72: 168-183. 1911.

Under laboratory storage at Norwood, England, the small grains tested deteriorated slowly over a 5- to 9-year period, followed by a rapid drop. Longevities were: Wheat and barley, 10 years; oats, 14 to 16 years; legumes, 10 to 15 years; and cruciferae species, about 10 years.

83. CARTER, E. P., and YOUNG, G. Y. Effect of moisture content, temperature, and length of storage on the development of "sick" wheat in sealed containers. Cereal Chem. 22: 418-428. 1945.

Wheat with 12.2 percent moisture developed "sick" effects in 279 days when stored at 40° C.; some symptoms were evident in 32 days in wheat with 18.6 percent moisture stored at 5° C. Higher temperatures and longer periods resulted in 100 percent "sick" kernels.

84. CARTER, E. P., and YOUNG, G. Y. Role of fungi in the heating of moist wheat. U. S. Dept. Agr. Cir. 838, 26 pp. 1950.

Heating of moist wheat was found to be due almost entirely to fungus respiration. Heating was controlled by vacuum storage, and by treating the grain with Ceresan at the rate of 0.48 gram per quart of grain.

85. CARTLEDGE, J. L., and BLAKESLEE, A. F. Mutation rate increased by aging seeds as shown by pollen abortion. Natl. Acad. Sci. Proc. 20: 103-110. 1934.

When the germination of datura seed was less than 50 percent, a mutation rate of 4.3 ± 0.7 percent was found as compared to 3.2 ± 0.2 percent for seeds of over 50 percent germination. The mutation rate for seeds 5 years or more in age was 7.9 ± 0.9 percent, whereas seeds less than 5 years old had only 2.7 ± 0.2 percent.

86. CHAMPION, H. G. Storage of seed of chir pine (*Pinus longifolia*). Indian Forester 56: 481-483. 1930.

Pine seed dropped from 82 percent germination to 72 percent at the end of 2 years when sealed in tin cans, and to 69 percent when mixed with charcoal and stored in a gunny sack under the roof of an open shelter.

87. CHEPIL, W. S. Germination of weed seeds. I. Longevity, periodicity of germination, and vitality of seeds in cultivated soil. Sci. Agr. 26: 307-346. 1946.

It was shown that many weed seed species remain viable in cultivated soils for over 6 years. Forty species were rated as having long to very long survival.

88. CHEPIL, W. S. Germination of weed seeds. II. The influence of tillage treatments on germination. Sci. Agr. 26: 347-357. 1946.

Weed seed that was buried in soil 5 years was given seven tillage treatments. Survival of tumbling mustard *Sisymbrium altissimum*, redroot pigweed *Amaranthus retroflexus*, and stinkweed *Thlaspi arvense* remained high with all treatments. Over a 5-year period treatments where soil was disturbed increased the early emergence of seedlings and reduced the numbers of seeds germinating.

89. CHILDS, J. F. L. A method of maintaining viability of citrus seed in storage. Citrus Indus. 29: 16-18, 20-21. 1948.

Thirty-four citrus varieties, after a treatment with 8-hydroxyquinone and stored for 6 months at 35° F., either in damp sawdust or damp sphagnum moss, had an average germination of 92.6 percent with no fungus infection.

90. CHILDS, J. F. L., and HRNCIAR, G. A method of maintaining viability of citrus seed in storage. Fla. State Hort. Soc. Proc. (1948) 61: 64-69. 1949.

After a surface treatment with a 1-percent solution of 8-hydroxyquinoline sulfate, 28 of 34 varieties of citrus stored at 35° F. in moist sawdust had 90 percent germination after 6 months and, in most cases, over 80 percent after 8 months.

91. CHING, T. M. Keeping field seed quality in storage and in transit. West. Feed and Seed 14: 21-22. 1959.

Seed of Chewings fescue stored for 3 years in a warehouse in Oregon maintained high viability for 18 months when the moisture content varied seasonally from 11 to 16 percent. The decline in germination was rapid after 18 months. Under simulated tropical conditions viability was completely lost in 8 months. Under simulated arctic and desert conditions the germination remained high. Estimated seed moisture contents for safe storage of 18 crops are given.

92. CHING, T. M., PARKER, M. C., and HILL, D. D. Interaction of moisture and temperature on viability of forage seeds stored in hermetically sealed cans. Agron. Jour. 51: 680-684. 1959.

Seed of crimson clover with 6 and 8 percent moisture maintained high viability for 3 years when sealed and stored under warehouse conditions at 38°, 22°, and 3° C. Ryegrass sealed at 6 and 8 percent lost no viability under warehouse storage, but the 8 percent moisture seed kept only 18 months at 38°. At 22° the 6 and 8 percent seed lost no viability. At 3° seed with 6, 8, 12, and 16 percent moisture retained initial germination.

93. CHING, T. M., TAYLOR, H., and JENSEN, L. A. Quality change of forage seeds in commercial storage in western Oregon. Assoc. Off. Seed Anal. Proc. (1959) 49 (1): 167-172. 1960.

When stored 25 months in burlap bags in fluctuating atmospheric conditions, there was a gradual drop the first 17 months in the germination of alta fescue and a slight drop in Chewings fescue, followed by a rapid drop. Storage had only a slight effect on viability of common ryegrass and highland bent. Sundan grass dropped from approximately 83 to 55 percent in the 2 years. Crimson clover remained highly viable for 1 year, followed by a gradual drop. Differences in germination were observed between seeds from the periphery and center of bags.

94. CHIPPINDALE, H. G., and MILTON, W. E. J. On the viable seeds present in the soil beneath pastures. Jour. Ecol. 22: 508-531. 1934.

Viable weed seeds were found under a pasture sod which had been unbroken for 68 years.

95. CHRISTENSEN, C. M. Grain storage studies. XVIII. Mold invasion of wheat stored at moisture contents below 15 percent. Cereal Chem. 32: 107-116. 1955.

Invasion of wheat with 13.5 to 15.0 percent moisture by aspergillus in a 16-month period led to the conclusion that 14.0 to 14.5 percent moisture in wheat is too high for safe storage.

96. CHRISTENSEN, C. M. Grain storage studies. XXI. Viability and moldiness of commercial wheat in relation to incidence of germ damage. Cereal Chem. 32: 507-518. 1955.

The germination of "sick" wheat was found to be always zero. With 84 percent of surface-disinfected wheat yielding storage molds, it was decided that the invasion by aspergillus is the cause of sick wheat.

97. CHRISTENSEN, C. M., and GORDON, D. R. The mold flora of stored wheat and corn and its relation to heating of moist grain. Cereal Chem. 25: 40-51. 1948.

Molds in corn and wheat increased in proportion to the moisture content. Temperatures of grain reached 45° C. regardless of the degree of inoculation, but grain with lower rates of inoculation reached the maximum temperature at a slower rate.

98. CHRISTENSEN, C. M., OLAFSON, J. H., and GEDDES, W. F. Grain storage studies. VIII. The relation of molds in moist stored cottonseed to increased production of carbon dioxide, fatty acids, and heat. Cereal Chem. 26: 109-128. 1949.

Increase in mold infection was closely correlated with production of carbon dioxide and increase in free fatty acids. Internal mold population was found to be high in the absence of external evidence.

99. CHRISTIDES, B. G. Seed vitality and other cotton characters as affected by the age of seed. Plant Physiol. 29: 124-131. 1954.

Cottonseed with 8 to 10 percent moisture was maintained with a high degree of viability when stored 6 years at 1° to 32° C. A 10-year storage period had a negligible effect on yields.

100. CLARK, C. F. Longevity of potato seed. Amer. Potato Jour. 17: 147-152. 1940.

Potato seed deteriorated rapidly when stored at room temperatures in envelopes, and moderately when sealed in bottles. Germination over a 10- to 13-year period remained high with a storage temperature of 40° F.; no loss in viability was encountered with storage at 32°.

101. CLAYTON, E. E. Effect of seed treatments on seed longevity. (Abstract) Phytopathology 21: 105-106. 1931.

This is a report of injury to seed that was stored after being treated with hot water, mercuric chloride, or liquid organic mercurial. The dust treatments usually had no injurious effects on seed in storage for short periods.

102. COCHRAN, H. L. Better methods of pimiento production. Ga. Agr. Expt. Sta. Bul. 218, 41 pp. 1941.

No storage experiments are included in this bulletin, but low temperatures and humidities are recommended.

103. COLEMAN, D. A., and FELLOWS, H. C. Hygroscopic moisture of cereal grains and flaxseed exposed to atmospheres of different relative humidity. Cereal Chem. 2: 275-287. 1925.

Hygroscopic moisture of the seeds at 75 percent relative humidity and 25° to 28° C. was found to be between 14.0 and 15.0 percent.

104. COLEMAN, D. A., ROTHGEB, B. E., and FELLOWS, H. C. Respiration of sorghum grains. U. S. Dept. Agr. Tech. Bul. 100, 16 pp. 1928.

Moisture content in several varieties of sorghum held at 25° to 28° C. ranged from 6.65 percent at 13.8 percent relative humidity to 28.04 percent at 100 percent.

105. COLEMAN, F. B., and PEEL, A. C. Storage of seeds. Queensland Agr. Jour. 74: 265-276. 1952.

Storage of several vegetable crop seeds in tin cans proved superior to storage in chlorinated rubber, waxed paper, cellophane, and paper containers. Storage with silica gel improved keeping qualities. Carrot and lettuce seeds had poorer keeping qualities than cucumber, beet, and cabbage seeds.

106. COLHOUN, J., and MUSKETT, A. E. A study of the longevity of the seed-borne parasites of flax in relation to the storage of the seed. Ann. Appl. Biol. 35: 429-434. 1948.

Fungi remained viable on flaxseed with 10 percent moisture for a period of 18 to 19 months. Germination of seed at the death of the parasites dropped as low as one-fourth of the original.

107. COLVIN, R., CRAIG, B.M., and SALLANS, H. R. Hygroscopic equilibria for hulls and kernels of sunflowerseed and oats. Canad. Jour. Res., Sect. F., Technol., 25: [111]-118. 1947.

At 75 percent relative humidity and 25° C., oats had 13.4 percent moisture, and seed of sunflowers 11.4 percent.

108. COMEAUX, D. J. The effect of cold storage on the viability of rice seed. La. Acad. Sci. Proc. (1945-46) 10: 184-187. 1947.

Several rice selections were stored successfully for 2 to 8 years at 50° C. and 50 percent relative humidity.

109. CONDON, M. Z., ANDREWS, F. R., LAMBOU, M. G., and ALTSCHUL, A. M. Inhibition of heating and lipolysis in seeds. Science 105: 525-527. 1947.

Diethyl oxalate applied to cottonseed at a concentration of 0.24 percent proved equal to a treatment of ethylene chlorhydrin at 0.38 percent in preventing heating and lipolysis.

110. CONDON, M. Z., LAMBOU, M. G., VIGNES, J. L., and others. Inhibitors of heating and deterioration in seeds. I. Ethylene chlorhydrin and related compounds. Plant Physiol. 24: 241-254. 1949.

Ethylene bromhydrin was 2.1 times as effective as ethylene chlorhydrin as an inhibitor of heating and formation of free fatty acids.

111. CONNOR, E. C. The storage and germination of apple seed. Agr. Gaz. N. S. Wales 58: 414-416. 1947.

This article covers general propagation of apples in New Zealand; it recommends short-term storage of seed in moist sand at 32° F.

112. COTTON, R. T., and GRAY, H. E. Preservation of grains and cereal products in storage from insect attack. In Preservation of grains in storage, F.A.O., U.N., Agr. Studies No. 2, pp. 35-71. 1948.

A review of the various methods used to prevent insect infestation, including fumigation, sanitation, bin construction, and control of moisture and temperature.

113. CROCKER, W. Storage, after-ripening, and germination of apple seeds. (Abstract) Amer. Jour. Bot. 15: 625-626. 1928.

This paper contains essentially the same information relating to apple seed storage as is given under reference number 117.

114. CROCKER, W. [Harvesting, storage, and stratification of seeds in relation to nursery practice.] Florists' Rev. 65 (1684): 43-46. 1930. (Professional Paper No. 15, Boyce Thompson Inst., March 1930.)

A marked drop in the viability of delphinium seeds was found after storage for 38 months in the laboratory, in either open or sealed containers. Air-dried seed stored at 7° F. kept satisfactorily except for one lot of American-grown seed.

115. CROCKER, W. Life-span of seeds. Bot. Rev. 4: 235-274. 1938.

A review of work related to seed longevity up to 1938, concluding that the most plausible cause of seed deterioration with age is degeneration of the nucleus, preventing normal mitotic division.

116. CROCKER, W. Growth of plants: Twenty years research at Boyce Thompson Institute. Pp. 28-66. New York. 1948.

A review of a number of reports in regard to seed deterioration. Particular attention is given to seed storage and deterioration. Precipitation of proteins is advanced as a likely cause of loss of viability.

117. CROCKER, W., and BARTON, L. V. After-ripening, germination, and storage of certain rosaceous seeds. Boyce Thompson Inst. Contrib. 3: 385-404. 1931.

Various Rosa species were stored dry (temperature not reported) for periods of 2 to 4 years. R. rugosa seed had better germination after 3 years than when fresh. R. multiflora dropped from 72.5 percent germination when fresh to one of 48.4 percent after 3 years, and R. setigera dropped from 53.4 to 35.6 percent after 2 years. Degeneration for all the Rosa species was generally slow. Seeds of some apples (Patten, Wealthy, and Greening) germinated almost as well after 2½ years of dry storage as seeds 1 and 1½ years old.

118. CROCKER, W., and BARTON, L. V. Physiology of seeds. 267 pp. Waltham, Mass. 1957.

A review covering most phases of seed physiology including anatomy, production, chemical composition, water relationships, respiration, germination, dormancy, storage, and metabolism.

119. CROCKER, W., and GROVES, J. F. A method of prophesying the life duration of seeds. Natl. Acad. Sci. Proc. 1: 152-155. 1915.

Loss of viability was attributed to the precipitation of proteins. Formula was given for the prediction of longevity.

120. CROCKER, W., and HARRINGTON, G. T. Catalase and oxidase content of seeds in relation to their dormancy, age, vitality, and respiration. Jour. Agr. Res. 15: 137-174. 1918.

Catalase activity of Johnsongrass and Sudangrass declined with age, but continued at a reduced rate in dead seed. Catalase activity was considered to be a good indication of age. Activity in embryo was found to be 28 to 29 times as high as that in the endosperm. Catalase activity and respiration rate were closely associated.

121. CROSIER, W. Effect of storage on treated seed wheat. Farm Res. [N. Y. State and Cornell Agr. Expt. Stas.] 12 (2): 4, 10. 1946.

This paper reports a short-term experiment that showed Ceresan to have no effect on the germination of wheat. Aeration of stored, treated seed is recommended.

122. CROSIER, W., and PATRICK, S. Longevity of hard seeds in winter vetch. Assoc. Off. Seed Anal. Proc. 42: 75-80. 1952.

No noticeable difference in germination between permeable and impermeable seed was found after 8 years of storage in a laboratory. Percentages of hard seeds decreased with age.

123. D'AMATO, F. The problem of the origin of spontaneous mutations. Caryologia (1952-53) 5: 1-13. [1952.]

A review of work covering the relation of both age and chemical compounds to mutations. End products formed during seed metabolism were considered to have mutagenic properties.

124. D'AMATO, F., and HOFFMAN-OSTENHOF, O. Metabolism and spontaneous mutations in plants. In Demerec, M., ed., Advances in Genetics 8: 1-28. 1956.

A complete discussion of literature covering mutations as associated with aging of seed, with the conclusion that end products during storage upset the nuclear mechanism or result in general toxicity.

125. DARLINGTON, H. T. The 50-year period for Dr. Beal's seed viability experiment. Amer. Jour. Bot. 18: 262-265. 1931.

The germination results of buried seed are given in tabular form. Several species were still viable.

126. DARLINGTON, H. T. The sixty-year period for Dr. Beal's seed viability experiment. Amer. Jour. Bot. 28: 271-273. 1941.

Seed of *Oenothera biennis*, *Rumex crispus*, and *Verbascum blattaria* germinated 24, 4, and 68 percent, respectively, after 60 years in the ground.

127. DARLINGTON, H. T. The seventy-year period for Dr. Beal's seed viability experiment. Amer. Jour. Bot. 38: 379-381. 1951.

Seed of Oenothera biennis had 14 percent germination; that of Rumex crispus, 8; and that of Verbascum blattaria, 72, after being buried 70 years.

128. DARROW, G. M., and SCOTT, D. H. Longevity of blueberry seed in cool storage. Amer. Soc. Hort. Sci. Proc. 63: 271. 1954.

When stored in a refrigerator at 40° F., 12-year-old seed of rabbiteye blueberry germinated 86.27 percent and 9-year-old seed of highbush germinated 59.0 to 63.5 percent.

129. DARSIE, M. L., ELLIOTT, C., and PEIRCE, G. J. A study of the germinating power of seeds. Bot. Gaz. 58: 101-136. 1914.

In the absence of fungi a higher rate of heat evolution was associated with young than with aged seed. "Normal" heat evolution charts are given for hemp, barley, wheat, oats, corn, and clover.

130. DAVIES, W. E. Storage of clover seed. I. First interim report, 1947-54. Brit. Grassland Soc. Jour. 11: 224-229. 1956.

Under laboratory conditions red clover began to decline in 3 years, and in 5 years had dropped to less than 10 percent germination. At 32° F. both red and white clovers retained their viability for 7 years. Seeds stored under vacuum and in nitrogen were shorter lived than those stored unsealed. Seeds sealed in air, however, were maintained at 80 percent germination.

131. DAVIES, W. L. The cause of deterioration of maize and maize meal. Fert., Feed. Stuffs and Farm Supplies Jour. [London] 13: 784-785. 1928.

A popular article directing attention to the fact that corn keeps indefinitely at 12 percent moisture and molds develop at 15 percent.

132. DECKER, A. E., and REITZ, L. P. Germination tests with flax stored at different moisture and temperature levels. Internatl. Seed Testing Assoc. Proc. 14: [27]-34. 1948.

At 40° F. flaxseed with moisture contents of 9, 11, and 13 percent kept perfectly for 940 days in storage. In the same period seed with 9 percent moisture stored at room temperature maintained high germination; those with 11 percent moisture dropped from 93 to 62 percent germination; and those with 13 percent moisture dropped to 50 percent. At 86° all seeds were dead at the end of 110 days.

133. DECKER, P. Lupine investigations. Fla. Agr. Expt. Sta. Ann. Rpt. 1948-49: 115-116. 1949.

Seed at 16 percent moisture stored under ideal conditions did not drop materially in germination at the end of 1 year. When sealed in Mason jars at 13.5 percent moisture, germination was little impaired at the end of 2 years. Above this percentage, decline was rapid.

134. DELAVAN, C. C. The relation of the storage of the seeds of some of the oaks and hickories to their germination. Mich. Acad. Sci. Rpt. (1915) 17: 161-163. 1916.

When stored either in a pit with a minimum temperature of -5° C. or in an icebox, averaging 95 percent relative humidity, at 1° to 8°, seed of hickory, white oak, and black oak retained high viability for 5 months. However, the viability dropped markedly when the seeds were dried to 5 percent moisture and stored under laboratory conditions or in sealed jars in the laboratory.

135. DENDY, A. Report on the effect of air-tight storage upon grain insects. Roy. Soc. [London] Grain Pests (War) Com. Rpt., Part I, 1: 6-24. 1918.

Hermetic sealing for 7 to 28 days was sufficient to kill most grain insects in wheats of different moisture content. Experiments were run in bottles and in bulk.

136. DENDY, A., and ELKINGTON, H. D. Report on the effect of air-tight storage upon grain insects. Roy. Soc. [London] Grain Pests (War) Com. Rpt., Part II, 3: 1-18. 1918.

Context essentially the same as in Report No. 1, Part I. (See above.)

137. DENDY, A., and ELKINGTON, H. D. On the prevention of heating in wheat by means of air-tight storage. Roy. Soc. [London] Grain Pests (War) Com. Rpt. 5: [3]-10. 1919.

The experiments involved wheat with 20.7 percent and 34.95 percent moisture. With aerated wheat of 20.7 percent moisture the temperature rose to 49.4° C., but little heating was experienced when the grain was sealed, although loss of viability did occur. Similar results were obtained for the 34.95 percent wheat. Heating was rapid at first, followed by a gradual drop and then a gradual increase.

138. DENT, T. V. Some records of extreme longevity of seeds of Indian forest plants. Indian Forester 68: 617-631. 1942.

Of 64 samples of various seeds obtained from exhibition cases at Dehra Dun, the oldest (with 1 remaining viable seed after 41 years) was Caesalpina dignya. Other samples remaining viable for 23 to 31 years were Acacia farnesiana, Cassia fistula, Albizzia lebbek, A. odorissima, Dechostachys cinera, A. decurrens, and Leucaena glauca. Hibiscus macrophyllus and Ochroma lagopus were partially viable after 24 years and Abutilon indicum after 17 years.

139. DEXTER, S. T. Storage of alfalfa seed in the presence of herbicides. Mich. Agr. Expt. Sta. Quart. Bul. 39: 647-649. 1957.

Alfalfa seed suspended over various herbicides in flasks in which dry conditions prevailed was not affected by the fumes.

140. DEXTER, S. T. Moisture equilibrium values in relation to mold formation of several grasses and small-seeded legumes. Agron. Jour. 49: 485-488. 1957.

Moisture contents of 14 grasses at 55 and 85 percent relative humidities averaged 11.0 and 16.2 percent, respectively. The respective moisture contents for nine legumes were 9.0 and 18.2 percent. Molds developed more freely on the grasses than on the legumes.

141. DEXTER, S. T., ANDERSON, A. L., and PFAHLER, P. L. Responses of pea beans to various humidities and temperatures of storage. Agron. Jour. 47: 246-250. 1955.

Moisture equilibria are given for humidities from 55 to 85 percent over a temperature range of 40° to 130° F. Equilibria were generally lower at higher temperatures. Averages at 80° ranged from 11.82 percent at 55 percent relative humidity to 18.04 percent at 85 percent relative humidity. High temperatures and high humidities were accompanied by severe deterioration.

142. DEXTER, S. T., and CREIGHTON, J. W. A method of curing farm products by the use of drying agents. Amer. Soc. Agron. Jour. 40: 70-79. 1948.

Different humidities were maintained in stored seed with wood blocks impregnated with saturated solutions of various chemicals. In 36 days 18.4 pounds of water were removed by impregnated blocks from one-half ton of soybeans. Moisture in oats was reduced from 16.5 to 12.5 percent in 12 days.

143. DE ZEEUW, D. J., GUYER, G. E., WELLS, A. L., and DAVIS, R. A. The effects of storage of vegetable seeds treated with fungicides and insecticides on germination and field stand. U. S. Agr. Res. Serv. Crops Res. Div., Plant Dis. Reporter 43: 213-220. 1959.

In a 3-year storage test organic fungicides alone and in combination with certain insecticides proved to be superior to mercury materials or to insecticides alone in regard to germination of Alderman peas, Round Pod Kidney wax beans, and National Pickling cucumbers. No increase in damage resulted from storage after seed treatment.

144. DILLMAN, A. C., and TOOLE, E. H. Effect of age, condition, and temperature on the germination of flaxseed. Amer. Soc. Agron. Jour. 29: 23-29. 1937.

Flaxseed stored in unsealed metal containers under prevailing temperatures at Mandan, N. Dak., remained highly viable for 13 to 16 years. High moisture content of seed at harvest was inducive to lower viability in storage.

145. DORPH-PETERSEN, K. How long do the various seed species retain their germination power? Internatl. Inst. Agr., Internatl. Rev. Sci. and Pract. Agr. (n.s.) 2: 283-301. 1924.

Of the many species studied at the Danish seed testing station under room conditions, the life durations of selected species were: 26 to 27 years for *Trifolium repens*, *T. hybridum*, and *Lotus corniculatus*; 16 to 17 years for *Medicago sativa*, *Phalaris canariensis*, *Sinapis alba* (= *Brassica hirta*), and *Pinus montana*. Seeds of *Cruciferae* were found to be fairly long lived, whereas *Umbelliferae* were short lived.

146. DRAKE, V. C. Decline in viability of lettuce seed during laboratory storage. Assoc. Off. Seed Anal. News Letter 22 (2): 31-33. 1948.

Normal and abnormal sprouts from lettuce seeds approximately 2 years old were compared with those from fresh seeds. Germination and normal seedlings decreased with age. In many cases, the 2-year-old seeds failed to produce normal seedlings.

147. DUTT, B. K., and THAKURTA, A. G. Viability of vegetable seeds in storage. Bose Res. Inst., Calcutta, Trans. (1953-55) 19: 27-36. [1956.]

In open storage, seeds of carrot, cabbage, cauliflower, and knolkhol lost viability in 9 months, but in sealed storage as water contents were reduced keeping qualities improved. Seed preserved in a desiccator retained viability for 8 years. Prior to loss of germination, defective germination (as evidenced by underdeveloped radicles) was observed.

148. DUVEL, J. W. T. The vitality and germination of seeds. U. S. Dept. Agr. Bur. Plant Indus. Bul. 58, 96 pp. 1904.

The longevity of the seed of several species was studied under atmospheric conditions in various sections of the United States. Onion seeds were found to be the poorest keepers; peas and corn kept well. Little loss in viability occurred when seeds were dried and sealed. It was concluded that respiration is not necessary for the maintenance of seed viability.

149. DUVEL, J. W. T. The effect of climatic conditions on the vitality of seeds. Presented before Amer. Assoc. Adv. Sci., 1905; cited in U. S. Dept. Agr. Off. Expt. Stas., Expt. Sta. Rec. (1904-5) 16: 618. 1905.

A review of work involving storage of seed at 60 different locations. Seed in unsealed containers deteriorated rapidly under high temperatures and humidities, whereas that in sealed containers maintained reasonably high viability. Seed stored in moderately warm climates showed little deterioration at the end of 1 year regardless of storage containers.

150. DUVEL, J. W. T. The vitality of buried seeds. U.S. Dept. Agr. Bur. Plant Indus., Bul. 83, 22 pp. 1905.

A report on viability of seed buried in clay pots in 1902. Weed seeds for the most part retained viability better than those of crop plants. Preservation was better at greater depths of burying.

151. DUVEL, J. W. T. The storage and germination of wild rice seed. In U. S. Dept. Agr. Bur. Plant Indus., Bul. 90, pp. 5-14. 1906.

Wild rice failed to germinate if allowed to dry. Wet cold storage is needed for preservation.

152. EASTHAM, A. The longevity of some common seeds. Agr. Gaz. Canada 1: 544-546. 1914.

After storage under room conditions at Ottawa, timothy, red clover, and alsike clover lost approximately half of their germination capacity in 10 years; oats maintained their original viability.

153. EDMOND, J. B. The influence of certain storage conditions and calcium oxide on the storage life of Golden Cross Bantam sweet corn seed. Amer. Soc. Hort. Sci. Proc. 73: 415-421. 1959.

Sweet corn seed stored 4 years unsealed at 40° F. lost only 7 percent germination; when stored in a warm room with 40 percent relative humidity, the germination loss was 17 percent. Inclosing calcium oxide at 3 and 5 percent by weight of seed resulted in an average loss in germination of 10 and 6 percent, respectively, over a 4-year period.

154. ELIASON, E. J. The storage of white ash seed. N. Y. State Conserv. Dept., Notes on Forestry Invest. 30, 3 pp. 1939.

Of various storage methods used for white ash seed, storage in sealed jars at 34° to 38° F. produced the best keeping qualities over a 3-year period. Seeds that were sealed and stored at fluctuating temperatures lost viability rapidly; under such temperature conditions cloth bags were superior to sealed jars.

155. EL-SHISHINY, E. D. H. Effect of temperature and desiccation during storage on germination and keeping quality of Kochia indica seeds. Jour. Expt. Bot. 4: [403]-406. 1953.

After 256 days of storage at Alexandria, Egypt, Kochia seedlots lost viability in 9, 10, and 12 months, respectively, when stored under laboratory conditions in an oven open to air at 30° C. and open to air at 38°. At 30° over $CaCl_2$ original germination was retained for 14 months.

156. EMSWELLER, E. The effect of age and temperature on germination of seed of Lilium speciosum rubrum. North Amer. Lily Soc., Lily Yearbook 4: 49-52. 1951.

The storage treatments in this study were of short duration and related to their effect on germination. The best germination was obtained when green seed was stored with moist vermiculite at 70° F.

157. EVANS, G. Red clover seed storage for 23 years. Brit. Grassland Soc. Jour. 12: 171-177. 1957.

Seed with an initial moisture content of 10.32 percent under laboratory conditions lost all viability in 23 years when untreated or sealed with CO_2. The incorporation of $CaCl_2$ or $CaCl_2$ plus CO_2 maintained the seed with an approximate loss of one-third the original viability with storage 23 years, either under laboratory conditions or at 32° to 41° F. Seed that was dried to a moisture content of 8.09 percent kept better than seed that was dried to 10.32 percent moisture.

158. EVANS, G. The viability over a period of fifteen years of severely dried ryegrass seed. Brit. Grassland Soc. Jour. 12: 286-289. 1957.

A continual but gradual drying of ryegrass seed at a 10° (C.) temperature increase every 3 hours (starting at 50°) produced in 18 hours a low moisture content of 0.66 at a final 3-hour temperature of 100°. A moisture content as low as this did not impair the germinability for a 7-year, sealed-in-air laboratory storage, and impaired it only a little during the eighth year; but in the final 7 years of storage, when the seed was kept in a cold room with nitrogen in place of the air in the closed bottles, the germination dropped to 57.7 percent, a greater loss than for seed subjected to less severe temperatures. On the other hand, seed dried for 15 hours to 1.62 percent moisture at a final 3-hour temperature of 90° had after the last 7 years a germination of 81 percent, greater than for seed subjected to less severe temperatures.

159. [EVANS, G., ROBERTS, H. M., and LEWIS, J.] Maintenance of life in seeds. Welsh Plant Breeding Sta., Aberystwyth, Rpt. 1950-56: 152-155. 1958.

Meadow fescue seed with 5 to 16.6 percent moisture, and timothy with 8 to 13.5 percent, maintained high viability when stored in cotton or cellophane bags at 32° F. Seed dried to 8 percent moisture and sealed kept as well in the laboratory as in cold storage. Storage in nitrogen had no advantage. Life in various seeds stored in a granary was most persistent in wild oats, followed by cultivated oats, barley, and wheat. Other parts of this station report are abstracted under reference numbers 157 and 158.

160. EVANS, H. Results of some experiments on the preservation of cacao seed in viable condition. Trop. Agr. [Trinidad] 27: 48-55. 1950.

The experiment reported was of only 13 weeks duration wherein cacao seed was successfully stored in charcoal of 30 to 35 percent moisture dry weight.

161. EWART, A. J. On the longevity of seeds. Roy. Soc. Victoria Proc. 21: 2-203. 1908.

A tabulation of reports of seed longevity that includes 3,000 tests. Tables show 42 species with a longevity of 100 to 200 years, also 11 species, mostly from Roman tombs which showed some life after 1,000 to 2,000 years.

162. EXELL, A. W. The longevity of seeds. Gard. Chron. (ser. 3) 89: 283. 1931.

A popular-type article calling attention to Ohga's lotus seed.

163. FAIRBROTHER, T. H. The influence of environment on the moisture content of flour and wheat. Cereal Chem. 6: 379-395. 1929.

Blending lots of wheat of high and low moistures on a 50-50 basis produced an interchange of moisture. Interchange of moisture between lots was rapid at first, but a 2-percent difference was maintained up to 220 hours.

164. FENTON, F. C. Storage of grain sorghums. Agr. Engin. 22: 185-188. 1941.

Practical aspects of drying sorghum are given with no research data. Equilibrium moisture contents are presented for 40°, 70°, and 90° F. over a humidity range of 10 to 100 percent.

165. FENTON, F. C., and SWANSON, C. O. Studies on the qualities of combined wheats as affected by type of bin, moisture and temperature conditions. I. Cereal Chem. 7: 428-448. 1930.

Eleven types of bins were tested, but wheat was not of uniform moisture content when stored. Ventilated bins appeared superior to other types. High rancidity developed whenever moisture exceeded 15 percent.

166. FIFIELD, C. C., and ROBERTSON, D. W. Milling, baking, and chemical properties of Marquis and Kanred wheat grown in Colorado and stored 25 to 33 years. Cereal Sci. Today 4: 179-183. 1959.

Seed of Marquis wheat stored 33 years and Kanred stored 30 and 33 years under atmospheric conditions failed to germinate, but the baking qualities of the flour were not materially affected. One-third of the stored samples showed a slight loss in proteins and a fairly regular increase in fat acidity.

167. FILLMORE, R. H. Growing rhododendrons from seeds. Arnoldia 9: 45-51. 1949.

This article contains no experimental work on seed preservation but recommends storing rhododendron seed in a refrigerator in sealed containers.

168. FISHER, E. A., and JONES, C. R. A note on moisture interchange in mixed wheats, with observations on the rate of absorption of moisture by wheat. Cereal Chem. 16: 573-583. 1939.

Wheats of high moisture percentages (20.65, 21.99, and 26.56) were combined with respective low moisture wheats (10.10, 12.62, and 11.36 percent) in 50-50 proportions. Mean differences in moisture content for the combinations of pairs were 2.44, 1.12, and 0.58 percent, respectively, over a period of 5 to 25 weeks.

169. FIVAZ, A. E. Longevity and germination of seeds of Ribes, particularly R. rotundifolium, under laboratory and natural conditions. U. S. Dept. Agr. Tech. Bul. 261, 40 pp. 1931.

No storage conditions of long duration were studied, but seeds of Ribes sprouting under upturned trees showed a longevity of 70 years in the soil.

170. FLEMION, F. After-ripening, germination, and vitality of seeds of Sorbus aucuparia L. Boyce Thompson Inst. Contrib. 3: 413-439. 1931.

Seed stored for 2 years at temperatures ranging from -8° C. to room temperature in sealed or unsealed containers, and under vacuum, was just as viable as freshly harvested seed. When the seed was stored at 25° C., either sealed or unsealed, vitality was rapidly lost. Seeds stored at room temperature over concentrated sulfuric acid or anhydrous calcium chloride at 50 or 75 percent humidity were injured. Seeds stored at 25 percent humidity were not affected. At lower than room temperatures the seeds tolerated both higher and lower relative humidities.

171. FLEMION, F. Physiological and chemical studies of after-ripening of Rhodotypos kerrioides seeds. Boyce Thompson Inst. Contrib. 5: 143-159. 1933.

In all cases when seeds of Jetbead were stored dry in open and sealed containers, or under vacuum for periods of from ½ to 2 years at temperatures ranging from -8° C. to room temperature, they gradually fell in vitality as the storage period was prolonged. When seeds were stored over various humidities maintained by the proper concentrations of sulfuric acid, no condition was found under which the vitality of the seeds was any better than that of the controls stored air-dry at room temperature. The most favorable storage condition for the seeds was found to be storage in open containers at 1°, 5°, and 10°.

172. FLORES, F. B. Viability of seeds of cotton as affected by moisture and age under different methods of storing. Philippine Jour. Agr. 9: 347-356. 1938.

This article compared keeping qualities of cottonseed sun-dried and stored in airtight containers vs. cotton air-dried and stored in burlap sacks. When seed was stored in burlap sacks after air drying, it was practically worthless at the end of a year. In sealed series acid-delinted seed dropped 45.6 percent; reginned, 29.2 percent; and fuzzy, 13.2 percent.

173. FOY, N. R. Deterioration problems in New Zealand Chewings fescue. New Zeal. Jour. Agr. 49: 10-24. 1934.

In an experiment as an adjunct to a study of shipping methods, seed of Chewings fescue was stored for 42 days with moisture contents of 5, 13, and 20 percent at 30°, 40°, and 50° C. Seed dried to 5 percent retained viability at all temperatures. Seed with 13 percent moisture dropped in germination at 30° only, from 97 to 75 percent. Seed with 20 percent moisture lost viability at all temperatures.

174. GANE, R. The water content of wheats as a function of temperature and humidity. Soc. Chem. Indus. Jour., Trans. and Commun. 60: 44-46. 1941.

The moisture equilibria of various wheats were determined for relative humidities from 5 to 98 percent. At 50 percent relative humidity the equilibrium averaged 13.8 percent moisture at 0° C.; 13.2 percent at 10°; and 12.5 percent at 20°--with only slight differences between "strong," "medium," and "weak" wheats.

175. GANE, R. The water content of the seeds of peas, soybeans, linseed, grass, onion and carrot as a function of temperature and humidity of the atmosphere. Jour. Agr. Sci. [England] 38: 81-83. 1948.

The hygroscopic percentages of seeds of several crops were determined as follows:

Relative humidity (Percent)	Chewings fescue	Pea	Carrot	Parsnip	Onion	Soybean	Linseed
10 - - - - - -	6.1	6.6	5.7	5.1	6.1	3.5	2.7
50 - - - - - -	10.5	11.2	8.4	8.7	10.3	7.8	6.6
70 - - - - - -	13.4	14.1	10.8	10.3	12.2	11.5	8.6

176. GANE, R. The effect of temperature, water content and composition of the atmosphere on the viability of carrot, onion and parsnip seeds in storage. Jour. Agr. Sci. [England] 38: 84-89. 1948.

Seeds of carrot, parsnip, and onion were stored at five relative humidities (10, 30, 50, 60, and 70 percent) and three temperature variables (0°, 10°, and 20° C.). Carrot seed showed little loss of viability under all treatments excepting the one of 20° and 70 percent relative humidity. Onion seed kept well at both 0° and 10° except with the 70-percent humidity. Viability of onion seed sealed in air and stored at 20° was superior to that sealed in nitrogen and stored at the same temperature. Storage conditions of 10° and 70 percent relative humidity were adverse to the longevity of parsnip seed. Moderate loss of viability of parsnip seed was encountered at 20° with low relative humidity.

177. GANE, R. The effect of temperature, humidity and atmosphere on the viability of Chewing's Fescue grass seed in storage. Jour. Agr. Sci. [England] 38: 90-92. 1948.

Chewings fescue was stored for 4 years in air, pure nitrogen, and nitrogen plus 1 percent oxygen at relative humidities of 45, 60, 70, and 80 percent. The effect of nitrogen was negligible. Rapid deterioration prevailed under all conditions at 30° C. Viability was maintained at all humidities and atmospheres at 0°. Little loss of viability was observed at 15° with 45 and 60 percent relative humidity.

178. GARRARD, A. The germination and longevity of seeds in an equatorial climate. Gardens' Bul. (Singapore) 14: 534-545. 1955.

Twenty-eight species of seed were stored in Singapore with conditions averaging 75° F. and 90 percent relative humidity. Only seeds with impervious seedcoats lasted 10 months, including Adenanthera pavonina, Asclepias curassavica, Ricinus communis, and Urena lobata. Some species deteriorated in 14 days, and most at the end of 2 or 3 months.

179. GAY, F. J. The effect of temperature on the moisture content-relative humidity equilibria of wheat. Austral. Council Sci. and Indus. Res., Jour. 19: 187-189. 1946.

At 20 percent relative humidity the moisture content of wheat was 1.2 percent lower at 100° F. than at 50°. At 90 percent relative humidity less than 1 percent difference was found between 90° and 50°.

180. GEORGE, E. J. Storage and dewinging of American elm seed. Jour. Forestry 35: 769-772. 1937.

Seed of Ulmus pumila stored under temperature variations from -28° to 115° F. for 1 year in closed and open containers germinated 79 and 77 percent, respectively.

181. GERASSIMOVA, H. The nature and causes of mutations. II. Transmission of mutations arising in aged seeds: Occurrence of "homozygous dislocants" among progeny of plants raised from aged seeds. Cytologia [Tokyo] 6: 431-437. 1935.

Progeny of the plants grown from 7-year-old seed of Crepis tectorum showed various abnormalities including abnormal leaves and inflorescences, arrested growth, and high sterility. Of 22 progeny plants 2 showed chromosomal mutation. In one line 12 out of 46 plants were mutants; in another line 17 out of 34 plants were mutants.

182. GIERSBACH, J., and CROCKER, W. Germination and storage of wild plum seeds. Boyce Thompson Inst. Contrib. 4: 39-51. 1932.

With an original germination of 71 percent in 180 days, wild plum (Prunus americana) had a germination of 45 percent in 181 days following a storage under moist conditions for 53 months at 7° to 10° C. Ninety-eight percent germination was obtained in 253 days after 26 months under laboratory temperatures, and 16 percent in 181 days at the end of 53 months.

183. GILMAN, J. C., and BARRON, D. H. Effect of molds on temperature of stored grain. Plant Physiol. 5: 565-573. 1930.

A rise in temperature of wheat, oats, and barley at 18 percent moisture from approximately 5.2° to 26.3° C. was attributed mostly to respiration of fungi.

184. GLADSTONES, J. S. The influence of temperature and humidity in storage on seed viability and hard-seededness in the West Australian blue lupin, Lupinus digitatus Forsk. Austral. Jour. Agr. Res. 9: [171]-181. 1958.

Investigation led to the conclusion that at room temperature and 70 percent relative humidity lupine seed would keep for a year with a hygroscopicity of 14 to 15 percent. A longevity of 2 years at room temperature was assumed with moisture at 13 to 14 percent.

185. GLASS, R. L., PONTE, J. G., Jr., CHRISTENSEN, C. M., and GEDDES, W. F. Grain storage studies. XXVIII. The influence of temperature and moisture level on the behavior of wheat stored in air or nitrogen. Cereal Chem. 36: 341-356. 1959.

When wheat was stored at either 20° or 30° C. with moisture contents of 14 to 18 percent, nitrogen storage somewhat delayed loss of viability at moisture contents above 15 percent, but was ineffective in prolonging viability more than 10 weeks beyond that of the grain stored in air. Decreases in nonreducing sugars were about equal when the wheat was stored in either air or nitrogen, but increases in reducing sugars were much lower under the nitrogen treatments, particularly for seed at high moisture levels stored at 30°. Nitrogen prevented mold growth at 30°.

186. GLOYER, W. O. China aster seed treatment and storage. N. Y. State Agr. Expt. Sta. Tech. Bul. 177, 41 pp. 1931.

Seeds of aster stored at Geneva, N. Y., under laboratory conditions were maintained with high germination for 3 years, and with moderately high germination for 4 years. Percentages of moisture for selected relative humidities were as follows: 6.67 at 20 percent, 8.32 at 40 percent, 10.69 at 60 percent, and 15.07 at 80 percent. Sealing seed in a fruit jar is recommended for storage.

187. GOLUBCHUK, M., SORGER-DOMENIGG, H., CUENDET, L. S., and others. Grain Storage Studies. XIX. Influence of mold infestation and temperature on the deterioration of wheat during storage at approximately 12% moisture. Cereal Chem. 33: 45-52. 1956.

After wheat was held with 18 percent moisture for 7 days and dried to 12 percent, it was sterilized and a portion inoculated with a suspension of Aspergillus spp. and Penicillium spp. When stored at 24° C. both the sterilized and inoculated maintained viability for 12 months, but the inoculated series had tenfold greater mold count than the sterilized. Storage at 38° caused the inoculated series to drop in germination from 63 to 30 percent and the disinfected series to drop from 93 to 3 percent.

188. GOODSELL, S. F., HUEY, G., and ROYCE, R. The effect of moisture and temperature during storage on cold test reaction of Zea mays seed stored in air, carbon dioxide, or nitrogen. Agron. Jour. 47: 61-64. 1955.

Seed of "weak" and "strong" hybrids that was sealed in cans containing air, CO_2, and N atmospheres of 8, 10, 12, and 14 percent moisture contents was stored for 5 years at temperatures of 0°, 40°, 60°, and 85° F. An atmosphere of CO_2 or N did not improve in cold test over that of air except in the case of a weak hybrid sealed in air with 12 percent moisture at 60° storage. Cold test germination tests on all lots were significantly lower after 1 to 1½ years.

189. GORMAN, L. W., and GREENWOOD, R. M. Effect of moisture content on the viability of Italian ryegrass seed in storage. New Zeal. Jour. Sci. and Technol., Sect. A., 33 (2): 58-61. 1951.

Seed of ryegrass with 96 percent germination was stored with 8.7, 11.2, 13.4, 16.1, and 19.0 percent moistures in equilibrium with relative humidities of 35, 53, 70, 83, and 89 percent, respectively, at 44° to 70° F. In 4 years seed with 8.7 and 11.2 percent moisture did not drop in viability; seed with 13.4 percent moisture dropped to about 67 percent germination. Seed with 16.1 percent moisture lost viability in 30 months, that with 19.0 percent in 18 months.

190. GOSS, W. L. The vitality of buried seeds. Jour. Agr. Res. 29: 349-362. 1924.

Of 107 species of seed buried for 20 years, 51 that were largely of a weedy nature retained some viability. Food cereals and legumes did not survive.

191. GOSS, W. L. Germination of flower seeds stored for ten years in the California State Seed Laboratory. Calif. Dept. Agr. Bul. 26: 326-333. 1937.

Of 64 flower seed species stored in tin cans under laboratory conditions, 86 percent retained 50 percent or more of their initial viability for 3 or more years, 66 percent for 5 or more years, and 25 percent for 10 or more years. Seeds belonging to the same genus had similar periods of longevity.

192. GOSS, W. L. Germination of buried weed seeds. Calif. Dept. Agr. Bul. 28: 132-135. 1939.

Seed of several serious California weeds were buried in 1932, and tests were made on germination in 1933, 1934, 1936, and 1938. Morning-glory, silverleaf nightshade, and Klamath weed showed no loss of viability. Johnsongrass, creeping mallow, and silversheath knotweed were low in germination, but under farm conditions they could be serious.

193. GOSS, W. L., and BROWN, E. Buried red rice seed. Amer. Soc. Agron. Jour. 31: 633-637. 1939.

Rice seed was buried in clay pots to simulate irrigated and nonirrigated conditions. Some varieties (Southern Blackhull and Southern Red) maintained a degree of viability at the end of 8 years. Supreme Blue Rose and Caloro (White) lost viability during the first year. Varieties kept better under irrigated conditions.

194. GRABE, D. F. Artificial drying and storage of smooth bromegrass seed. Agron. Jour. 49: 161-165. 1957.

Bromegrass seed stored at a relative humidity of 80 percent had died (20° and 30° C. storage temperatures) or was deteriorating (10° storage) at the end of 26 months. Fifty percent relative humidity was satisfactory for storage at 10° and 20°. No loss in germination was noted with 20-percent relative humidity and temperature of 10°. A moisture content of 12 percent was found to be safe for storage.

195. GRIFFITH, A. L. Storage of seed of Prosopis species. Indian Forester 71: 251-252. 1945.

In a 2-month storage experiment at Dehra Dun, seeds of *Prosopis juliflora* and *P. glandulosa* stored in open bottles had higher germination than those stored in sealed bottles, whether sealed with or without paradichlorobenzene. Seeds of *P. juliflora* were adversely affected by naphthalene, but those of *P. glandulosa* were not. In a second test involving 10 to 50 times the recommended rates, paradichlorobenzene apparently reduced the germination of *P. glandulosa* but naphthalene was not deleterious.

196. GRIFFITHS. A., Jr. Culture and classification of *Camellia* and related genera. Fla. Agr. Expt. Sta. Ann. Rpt. 1954-55: 111. [1955.]

Seed of *Camellia japonica* retained viability for a year at 40° F. when stratified under open moist conditions, or when stored under sealed dry conditions; but seed did not retain viability under moist airtight stratification.

197. GROGAN, C. O., ZUBER, M. S., BROWN, H. E., and others. Effect of fungicides and insecticides on the germination of corn after storage. U. S. Agr. Res. Serv. Crops Res. Div., Plant Dis. Reporter 43: 1132-1137. 1959.

Over an 18-month storage period, corn dropped in germination in all treatments, but there followed by the end of the period a marked improvement in the case of the corn that had received fungicide or fungicide-insecticide treatments. In the case of insecticide treatments, after a rapid decline in germination the first 6 to 12 months, the corn showed only slight improvement. Maximum drop in germination in the best two treatments was approximately 5 percent in the 18-month period.

198. GROVES, J. F. Temperature and life duration of seeds. Bot. Gaz. 63: 169-189. 1917.

The life expectancy of Turkey wheat was determined by a formula based on the rate of coagulation of proteins at different temperatures and temperature durations. Predicted life of wheat with 9.0 percent moisture stored at 0° C. was 938 years, and with 12 percent moisture 393 years.

199. GUNTHARDT, H., SMITH, L., HAFERKAMP, M. E., and NILAN, R. A. Studies on aged seeds II. Relation of age of seeds to cytogenetic effects. Agron. Jour. 45: 438-441. 1953.

It was found that decreased viability in wheat, barley, rye, and peas in storage had parallel cytogenetic changes. It was estimated that the changes involved were equivalent to an X-ray dosage of 25.2 r., insufficient to account for all the cytogenetic changes.

200. HABER, E. S. Longevity of the seed of sweet corn inbreds and hybrids. Amer. Soc. Hort. Sci. Proc. 55: 410-412. 1950.

Seeds of various hybrids and inbred lines of sweet corn were held for 7 years at 30° to 90° F. and 30 to 60 percent relative humidity under ordinary seed storage. In general, the viability of the hybrids was maintained better than that of component inbreds. A definite drop in viability of all lines occurred after the third year. The degree of longevity appeared to be inherited. Crosses of short-lived inbreds produced short-lived hybrids; crosses of long-lived inbreds resulted in long-lived hybrids.

201. HAFERKAMP, M. E. Germination and other tests on superannuated cereal seeds. Assoc. Off. Seed Anal. Proc. 39: 111-114. 1949.

Seeds of wheat, oats, barley, and rye were stored in a laboratory at Pullman, Wash., both threshed and in the head, for 26 to 28 years. Of 115 varieties of wheat 3 had germination percentages from 14.4 to 39.2. These percentages for six varieties of oats ranged from 1.1 to 89.0, and for nine of barley from 1.8 to 100.0. Of six varieties of rye none retained their viability. Old seeds showed more evidence of chromatic bridging than young.

202. HAFERKAMP, M. E., SMITH, L., and NILAN, R. A. Studies on aged seeds I. Relation of age of seed to germination and longevity. Agron. Jour. 45: 434-437. 1953.

Seeds of several crops were stored at Lind, Wash., under a temperature range with extremes of -4.5° F. and 104.6° for 1 to 33 years. Barley, oats, wheat, corn, alfalfa, and peas were long lived. No rye varieties survived after 24 to 32 years of storage.

203. HALL, C. W. Drying temperatures and storage problems of sugar beet seeds. Amer. Soc. Sugar Beet Technol. Jour. 9: [161] -166. 1956.

At given relative humidities the moisture content of sugar beet seed was consistently greater at low than at high temperatures. At 90 percent relative humidity and 90° F., the seed had a moisture content of about 17 percent, approximately the moisture content at 70 percent and 40°.

204. HALL, D. W., and HYDE, M. B. The modern method of hermetic storage. Trop. Agr. [Trinidad] 31: 149-160. 1954.

Grain storage in pits and silos in various parts of the world is discussed. No experimental work was involved.

205. HAMID, M. A. Longevity of cotton seed delinted with sulphuric acid. Empire Cotton Growing Rev. 15: 312-314. 1938.

Delinting of cottonseed with sulphuric acid did not lower the germination as determined after a year of storage.

206. HAMILTON, R. A. A study of germination and storage life of Macadamia seed. Amer. Soc. Hort. Sci. Proc. 70: 209-212. 1957.

Macadamia seed stored at room temperatures (65° to 80° F.) kept satisfactorily for 4 months but thereafter deteriorated until total loss of viability occurred in 12 months.

207. HANSON, C. H., and MOORE, R. P. Viability of seeds of eight forage crop plants stored under subfreezing conditions. Agron. Jour. 51: 627. 1959.

Seeds of six legumes and two grasses were stored for 4 years at -7° to -11° C. with no loss in germination.

208. HARRINGTON, J. F. Drying, storing and packaging seed to maintain germination, vigor. [Part 1.] Seedsmen's Digest 11 (1): 16, [56-57], 64, [66], 68. 1960.

A general discussion of moisture relationships in seeds to storage conditions. Moisture equilibria for 36 crops under several relative humidities are given. Cause of deterioration is postulated as local exhaustion of food reserves under high moisture contents not high enough to allow for translocation of reserves.

209. HARRINGTON, J. F. Preliminary report on the relative desirability of different containers for storage of several kinds of vegetable seed. Calif. Col. Agr., Vegetable Crops Series No. 104, 8 pp. 1960.

As moisture barriers for the storage of seeds the following materials were worthless: (1) 4-ply 50-pound kraft paper, (2) 3-ply 50-pound kraft plus 1-ply 1/10-pound polyethylene, (3) 2-ply 1/10-pound polyethylene on 70-pound crepe kraft paper plus 2-ply 50-pound kraft. The addition of a high density polyethylene liner to (2) above was of doubtful value. High density 6-mil polyethylene bags, and those made of 3-ply 50-pound kraft plus 1-ply 1/10-pound polyethylene on 50-pound kraft were good moisture barriers. Pouches of aluminum foil laminated between two layers of polyethylene, and tin cans were completely resistant to moisture penetration.

210. HARRINGTON, J. F. Thumb rules of drying seed. Crops and Soils 13 (1): 16-17. 1960.

In addition to recommendations for seed drying general rules for seed storage are given. Storage periods without a serious drop in viability are double for each one percent decrease in seed moisture content or for each drop of 10° F. in storage temperatures.

211. HARRIS, R. H., and WALSTER, H. L. Observations on a sixty-four year old wheat sample. Cereal Chem. 30: 58-62. 1953.

"Power" wheat kept tightly stoppered since 1888 had lost viability. Other tests were concerned with milling and baking. There was evidence that some of the proteins had coagulated.

212. HARRISON, B. J. Seed storage. John Innes Hort. Inst. [London] Ann. Rpt. (1955) 46: 15-16. 1956.

This reference is a short note on the preservation of seeds of 20 varieties of lettuce and 1 variety each of onion and parsnip sealed in air and CO_2 for 6 years. The only seeds remaining viable were those in CO_2. The onion and parsnip seeds germinated, but only 6 of the 20 varieties of lettuce remained viable.

213. HARRISON, B. J., and McLEISH, J. Abnormalities of stored seed. Nature [London] 173: 593-594. 1954.

Lettuce and onion seeds sealed in CO_2 and stored at room temperatures were superior to the seed sealed in air. Seed sealed in air was superior to unsealed seed stored under laboratory conditions. Seed of lettuce stored sealed gave higher yields than did the seed stored unsealed; yields from sealed seed equalled those obtained from fresh seed. Chromosome aberrations were more frequent in lettuce seed of low germination than of high germination. Chromosome aberrations were not observable in aged onion seed, leading to the conclusion that chromosome breakages do not parallel age.

214. HAUCH, L. A. The cultivation of the oak (Quercus pedunculata) in Denmark. Quart. Jour. Forestry 17: 35-50. 88-97. 1923.

This paper relates only to the overwintering of acorns, for which a closed storage area permitting ventilation is recommended. Moderate humidity and temperatures near freezing are recommended.

215. HEIT, C. E. Storage of conifer seed. New York Nursery Notes No. 10, pp. 2-3. 1941.

Although this reference appears not to involve original research, it reports that storage of tree seeds was best in sealed containers at 34° to 38° F. with moisture content below 8 percent. Under these conditions seeds of Thuja occidentalis and Abies balsamea retained their viability for 5 years. Pinus resinosa appeared most tolerant of poor storage conditions, followed in decreasing order by spruces, firs, larches, and cedars. Hard pines had greater tolerances than soft pines.

216. HEIT, C. E. Recent findings on laboratory germination and longevity of New Zealand spinach seed. Assoc. Off. Seed Anal. Proc. (1943-44) 35: 115-120. 1945.

Spinach seed, stored under laboratory conditions at Geneva, N. Y., with an initial germination of 64 to 78 percent, had a germination of 88 percent after 9 years, and 95 percent after 10 years.

217. HERMANN, E. M., and HERMANN, W. The effect of maturity at time of harvest on certain responses of seed of crested wheatgrass, Agropyron cristatum (L.) Gaertn. Amer. Soc. Agron. Jour. 31: 876-885. 1939.

Storage of the seed of crested wheatgrass for 525 days increased the germination for late-milk stage, soft-dough stage, and 50-percent-shattered by the following percentages, respectively: 1 to 64, 8 to 88, and 74 to 94.

218. HILLS, K. L. Dormancy and hardseededness in T[rifolium] subterraneum. I. The effect of time of harvest and of certain seed storage conditions. Austral. Council Sci. and Indus. Res., Jour. 15: 275-284. 1942.

Percentage of hard seed decreased after storage for 13 weeks, with seed in tins placed in the sun showing the greatest decrease. Under different relative humidities and temperatures the greatest decrease in hard seed occurred at 12° C. and 10 percent relative humidity for two varieties, and at 37° and 10 percent for another. A condition of 37° temperature and 80 percent relative humidity was found not to be injurious for the duration of the test.

219. HODNETT, G. E. The effect of temperature and moisture during storage on the viability of grass seed. Trop. Agr. [Trinidad] 35: 208-212. 1958.

Seed of *Ixophorus unisetus* stored 2 years under temperature range of 20° to 80° F. and with moisture contents of 0.5 to 18.5 percent was preserved at 0.5 percent moisture and 80° temperature, with a germination of 55.6 (also 58.5) percent. Seed having 0.5 percent moisture stored at 20° had a viability of 40.3 (also 52.4) percent. Results lacked consistency, but it was concluded that control of only the moisture content or the storage temperature is necessary.

220. HOLMAN, L. E., BARRE, H. J., COTTON, R. T., and WALKDEN, H. H. Storage of dry shelled corn in farm-type bins. U. S. Dept. Agr. Cir. 826, 36 pp. 1949.

A study of corn storage through the cornbelt, with recommendations given for satisfactory storage. Temperatures, moistures, and insect infestation were studied. Drop in germination was associated with increases in fat acidity.

221. HOLMAN, L. E., and CARTER, D. G. Soybean storage in farm-type bins; a research report. Ill. Agr. Expt. Sta. Bul. 553, pp. [449]-496. 1952.

Soybeans stored with 8 to 9 percent moisture dropped only 8 percent in germination in 700 days with an increase of 14 units in fat acidity. With moisture at 12.0 to 12.5 percent, deterioration was gradual and fat acidity rose 25 units. With 13.0 to 14.0 percent moisture, germination dropped rapidly in 200 days, with an increase in fat acidity from 5 to 46 units.

222. HOPKINS, E. F., RAMERIZ SILVA, J. F., PAGAN, V., and VILLAFAÑE, A. G. Investigations on the storage and preservation of seed in Puerto Rico. Puerto Rico Agr. Expt. Sta. Bul. 72, 47 pp. 1947.

Onion, lettuce, radish, and buckwheat seeds kept well for 772 days at 80° F. and 20 percent relative humidity. With temperatures of 35° to 80° and relative humidities of 20 to 50 percent, beans and cottonseed held up well for 19 months, seed of pepper for 189 days, tomato for 519 days, and eggplant and cucumber for 772 days.

223. HOUSTON, D. F., FERREL, R. E., HUNTER, I. R., and KESTER, E. B. Preservation of rough rice by cold storage. Cereal Chem. 36: 103-107. 1959.

Rice was stored at 34°, 20°, and -20° F. with moisture contents from 12.0 to 15.9 percent. Storage was satisfactory with all moisture levels at 20°. To preserve rice satisfactorily at 34°, less than 13.0 percent moisture was required.

224. HOUSTON, D. F., STRAKA, R. P., HUNTER, I. R., and others. Changes in rough rice of different moisture content during storage at controlled temperatures. Cereal Chem. 34: 444-456. 1957.

Moisture contents of 13.8 percent at 70° F., and 11.0 percent at 90°, were found satisfactory for storage of rice over a 7-month period. During storage there was an increase in reducing sugars and fat acidity, and a decrease in nonreducing sugars. Loss of germination was associated with increase of reducing sugars and fat acidity.

225. HUBBARD, J. E., EARLE, F. R., and SENTI, F. R. Moisture relations in wheat and corn. Cereal Chem. 34: 422-433. 1957.

Adsorption and desorption of wheat and corn were studied at several relative humidities. Sigmoid curves resulted for both. Negative correlation was found between temperature and hygroscopic capacity, a 10° F. rise causing a drop of 1.3 percent in moisture of grain. Moisture after desorption was generally higher than after adsorption, the largest increase for wheat being 1.61 percent and for corn 1.62 percent at 22 and 33 percent relative humidity, respectively.

226. HUME, P. F. Storage of tea seed. Ceylon Tea Res. Inst. Tea Quart. 26: 93-95. 1955.

Tea seed stored in paper-lined wooden boxes was kept 6 months without loss of viability.

227. HUMMEL, B. C. W., CUENDET, L. S., CHRISTENSEN, C. M., and GEDDES, W. F. Grain storage studies. XIII. Comparative changes in respiration, viability, and chemical composition of mold-free and mold-contaminated wheat upon storage. Cereal Chem. 31: 143-150. 1954.

Mold-free wheat was conditioned to moisture contents from 14.9 percent to 30.7 percent and either sterilized or inoculated with mold. Mold-free grain respired at a uniform rate whereas the inoculated showed a rapid rise. Germination of seed stored 19 days was injured by moisture content at 14.9 percent, as was also mold-contaminated wheat with moisture content at 14.9 percent.

228. HUMPHRIES, W. R., and HURST, W. M. Moisture changes in some agricultural products due to atmospheric conditions. Agr. Engin. 16: 8-12. 1935.

Moisture equilibria are given for corn, flax, oats, rice, soybeans, sorghum, wheat, and seed cotton at relative humidities of 65 to 85 percent and temperatures from 60° to 70° F. Temperature differences at constant relative humidities had little effect on moisture content.

229. HUNTER, I. R., HOUSTON, D. F., and KESTER, E. B. Development of free fatty acids during storage of brown (husked) rice. Cereal Chem. 28: 232-239. 1951.

Rice was stored 22 weeks with moisture at 3.9, 6.6, 9.5, 11.8, and 14.1 percent at the temperatures of 0° to 2°, 25°, and 35° C. Free fatty acids increased as both moisture content and temperature increased. Fourfold reduction in free fatty acids was found at 25° when moisture was reduced from 14.1 to 9.5 percent, and a sixteenfold reduction when moisture was reduced from 14.1 to 3.8 percent.

230. HURD, A. M. Seed-coat injury and viability of seeds of wheat and barley as factors in susceptibility to molds and fungicides. Jour. Agr. Res. 21: 99-122. 1921.

Owing to the nature of saprophytes, wheat with rupture in the seedcoat is often invaded by molds. It was found that intact coats afforded absolute protection. Invasion was more rapid when the rupture was over the endosperm than when it was over the embryo. Sound seed subjected to 10° C. was sometimes invaded when germinated at room temperatures. Penicillium mold required a relative humidity of 80 percent and aspergillus mold 70 percent for their development.

231. ISAAC, L. A. Cold storage prolongs life of noble fir seed. Jour. Forestry 28: 571. 1930.

This is a half-page report on preservation of pine seed for 3 to 5 years at 15° F. Seed with an initial viability of 58 percent had 34 percent germination after 4 years. In a later test, seed with 38 percent sound seed germinated 13.5 after 3 years.

232. ISAAC, L. A. Cold storage prolongs the life of noble fir seed and apparently increases germinative power. Ecology 15: 216-217. 1934.

Seed of noble fir was stored at Portland, Oreg., for 5 years at 15° F. with little or no loss in viability. The methof of storage is not given.

233. JAMES, N., and LEJEUNE, A. R. Microflora and the heating of damp stored wheat. Canad. Jour. Bot. 30: [1]-8. 1952.

Attributed heating of wheat with 18.5 percent moisture to development of microorganisms.

234. JENSEN, E. A., LAMBOU, M. G., and ALTSCHUL, A. M. Research on the storage of cottonseed. Cotton Gin and Oil Mill Press 51 (2): 11-12, 31, 34-35. 1950. (Ann. Rpt., Natl. Cottonseed Prod. Assoc. Fellow for the Year 1949.)

Heating in cottonseed was prevented for 73 days by treatment with a mixture of propylene glycol dipropionate and 1,3-dimethyl-4, 6-bischloromethylbenzene at the rate of 30 pounds per ton.

235. JENSEN, E. A., LAMBOU, M. G., ALTSCHUL, A. M. Research on storage of cottonseed. Cotton Gin and Oil Mill Press 52 (4): 17, 44-45. 1951. (Ann. Rpt., Natl. Cottonseed Prod. Assoc. Fellow for the Year 1950.)

With moisture remaining constant at 20 percent, heating to 100° and 120° F. had no effect on viability of cottonseed. Heating to 120° for 30 minutes produced a 10-percent increase in viability; heating to 160° for 10 minutes killed the seed. Heating to 140° for 10 minutes increased viability 18 percent.

236. JENSEN, E. A., LAMBOU, M. G., ANDREWS, F. R., and others. The storage of cottonseed. IX. Behavior of cottonseed during storage under mill conditions. Amer. Oil Chem. Soc. Jour. 28: 241-245. 1951.

This study sampled bulk seed in Mississippi, Louisiana, and Georgia. Free fatty acids were found to be in direct proportion to initial moisture content. Aeration tended to limit development of free fatty acids in seed with low initial moisture.

237. JENSEN, E. A., LAMBOUR, J. S., LAMBOU, M. G., and ALTSCHUL, A. M. Research on the storage of cottonseed. Cotton Gin and Oil Mill Press 53 (5): 68-69, 84-85. 1952.

A number of organic solids were tested, and classified in three groups as: (1) Inhibitory of mold growth and heating, (2) inhibitory of heating only, (3) noneffective in inhibiting mold growth or heating.

238. JOHNSON, A. G. The role of fungi in the deterioration of grains in storage. In Preservation of grains in storage, F.A.O., U.N., Agr. Studies No. 2, pp. 88-91. 1948.

A short review of work showing that heating of grain and development of sick wheat are due to the respiration of fungi rather than of the grain itself.

239. JOHNSON, L. P. V. Effect of humidity on the longevity of Populus and Ulmus seeds in storage. Canad. Jour. Res., Sect. C., Bot. Sci., 24: 298-302. 1946.

At 20 percent relative humidity and room temperature the germinability of P. tremuloides was maintained at a high level for 455 days and that of P. grandidentata for 555 days. The optimum relative humidity for 4 Ulmus species was found to be in the range of 20 to 50 percent.

240. JONES, D. B., and GERSDORFF, C. E. F. The effect of storage on the protein of wheat, white flour, and whole wheat flour. Cereal Chem. 18: 417-434. 1941.

When wheat was stored for 24 months at 30° and 76° F., a decrease in solubility of proteins resulted. A partial breakdown of proteins, presumed to be caused by enzymatic activity, was indicated by a decrease in true proteins.

241. JONES, J. W. Germination of rice seed as affected by temperature, fungicides, and age. Amer. Soc. Agron. Jour. 18: 576-592. 1926.

Underwater germination tests of eight varieties of rice 1 to 6 years old showed that a relatively high germination could be maintained in a dry atmosphere for 3 years. Some varieties had high germination after 5 or 6 years of storage.

242. JOSEPH, H. C. Germination and keeping quality of parsnip seeds under various conditions. Bot. Gaz. 87: 195-210. 1929.

Ripe parsnip seed with 6.33 percent moisture, stored in paper bags at room temperature, lost 20 percent of initial germination in 2 years and 60 percent in 3 years. Seed dried at 0.40 to 1.7 percent moisture was high in germination when stored sealed at room temperature or at 5° to 7° C.

243. JUSTICE, O. L., and WHITEHEAD, M. D. Viability of velvetbean, Stizolobium spp., seed as affected by date of harvest, weathering, storage, and lodging. Amer. Soc. Agron. Jour. 34: 1000-1009. 1942.

Results show that velvetbeans in Alabama should be harvested in November or early December. Hulled and unhulled seed showed no consistent differences in germination from harvest to the April following. Commercial lots depreciated little when they were stored in laboratory for 1 year.

244. KAIHARA, H. Comparative storage-tolerance of some cereal grains in Japan. Ōhara Inst. f. Landw. Forsch. [Kurashiki, Japan] Ber. 9: [435]-440. 1951.

When stored in straw bags seeds of corn, naked barley, and wheat lost all viability in 2 years, rice in 8 months. When stored in tin containers high germinations of corn, naked barley, and wheat were maintained for 32 months, for rice 18 months.

245. KALOYEREAS, S. A. A gas storage for preserving rough rice. Rice Jour. 58 (2): 40-42. 1955.

Rice with 20.8 percent moisture remained in good condition after 6 months when stored at room temperature in an atmosphere of 30-percent CO_2 with 1,000 p.p.m. of ethylene oxide in the gas mixture.

246. KARON, M. L. Hygroscopic equilibrium of cottonseed. Amer. Oil Chem. Soc. Jour. 24: 56-58. 1947.

At 75 percent relative humidity and 25° C. whole cottonseed had a moisture content of 11.4 percent, the meats 10.0 percent, and the hulls 13.7 percent.

247. KARON, M. L., and ADAMS, M. E. Note on the hygroscopic equilibrium of cottonseed and cottonseed products. Amer. Oil Chem. Soc. Jour. 25: 21-22. 1948.

The moisture content of cottonseed at 11.1 percent relative humidity was found to be 3.9 and 4.5 percent for whole and delinted seed, respectively. Corresponding moisture percentages were 11.4 and 11.9 at 75.4 percent relative humidity, and 20.0 and 22.45 at 92.5 percent humidity.

248. KARON, M. L., and ADAMS, M. E. Hygroscopic equilibrium of rice and rice fractions. Cereal Chem. 26: 1-12. 1949.

At 25° C. the percent moisture in whole rice was found to be 14.0, in artificially dried rice 13.2, and in polished rice 15.6.

249. KARON, M. L., and ALTSCHUL, A. M. Effect of moisture and of treatments with acid and alkali on rate of formation of free fatty acids in stored cottonseed. Plant Physiol. 19: 310-325. 1944.

Very little change in fat acidity was found when cottonseed was stored 200 days at moisture contents of 7.5 and 10.5 percent. There was a slight rise in acidity at 15.5 percent moisture, and a rapid rise at 18.0 and 20.5 percent with mold development evident. Free fatty acids developed slowly over a 250-day period when seed was treated with ammonia gas to raise the pH to between 7.0 to 7.9. Treatment with ammonia or hydrogen chloride destroyed viability.

250. KARON, M. L., and ALTSCHUL, A. M. Respiration of cottonseed. Plant Physiol. 21: 506-521. 1946.

Cottonseed with moisture contents from 10.0 to 15.7 percent (the seed conditioned if necessary) was stored in airtight jars at 25° C. It was found that the respiration quotient (R.Q.), the rate of CO_2 evolved to oxygen absorbed, was 1. Formulas are given for determination of respiration as influenced by moisture content.

251. KARON, M. L., and HILLERY, B. E. Hygroscopic equilibrium of peanuts. Amer. Oil Chem. Soc. Jour. 26: 16-19. 1949.

Whole peanuts had a moisture content of 10.5 percent, kernels of 8.8 percent, at 75 percent relative humidity and 25° C.

252. KARPER, R. E. Longevity and viability of kafir seed. Amer. Soc. Agron. Jour. 20: 527. 1928.

Kafir seed stored under atmospheric conditions at College Station, Tex., lost only 12 percent viability in 7 years and 23 percent in 10 years.

253. KARPER, R. E., and JONES, D. L. Longevity and viability of sorghum seed. Amer. Soc. Agron. Jour. 28: 330-331. 1936.

Sorghum seed stored under prevailing conditions at Lubbock, Tex., dropped gradually in germination over a 9-year period, then in the following 10 years dropped rapidly to 0.5 percent.

254. KASTOFF, D. Mutations and the ageing of seeds. Nature [London] 135: 107. 1935.

A short note attributing the discovery of mutations in aging seed to DeVries in 1901.

255. KEARNS, V., and TOOLE, E. H. Relation of temperature and moisture content to longevity of Chewings fescue seed. U.S. Dept. Agr. Tech. Bul. 670, 27 pp. 1939.

The best storage conditions for imported Chewings fescue seed over a 37-month period were found to be -10° C. for seed with high moisture content and 2° for seed with low moisture content. Seed of Chewings fescue stored with 10 percent moisture at 20° kept well for 2 years 12 weeks. Domestic seed with 10 percent moisture kept for 2 years at 20° as well as it did at lower temperatures. Temperatures from 2° to 10° were required to satisfactorily store seed of 14 percent moisture.

256. KELLY, C. F. Methods of ventilating wheat in farm storages. U. S. Dept. Agr. Cir. 544, 74 pp. 1940.

A study of the storage of seed in various locations in the Wheat Belt indicated that moistures of 13.0 to 13.5 percent were permissible in western Kansas and of 14.0 to 14.5 percent in North Dakota. Horizontal ventilators in bins were superior to vertical.

257. KELLY, C. F., STAHL, B. M., SALMON, S. C., and BLACK, R. H. Wheat storage in experimental farm-type bins. U. S. Dept. Agr. Cir. 637, 245 pp. 1942.

In studying wheat storage in the Wheat Belt a drop in germination was found to be associated with total damage and increased fat acidity. Best quality in wheat was obtained with forced ventilation, except in Illinois. Maximum safe moisture at Hays, Kans., was found to be 15.0 percent unless the storage was ventilated.

258. KIESSELBACH. T. A. Effect of artificial drying upon the germination of seed corn. Amer. Soc. Agron. Jour. 31: 489-496. 1939.

Corn was dried to 5 percent moisture without injury at 107° to 112° F. when initial moisture did not exceed 38 percent. When moistures reached 50 percent prolonged heating at 112° resulted in injury.

259. KINCAID, R. R. Effect of storage conditions on the viability of tobacco seed. Jour. Agr. Res. 67: 407-410. 1943.

When tobacco seed was stored with 9 percent moisture in a refrigerator, viability was maintained for 10 years. High germination was maintained also when the seed was stored in a laboratory, in an attic, or in a basement with relative humidity of 1 percent. Germination remained high when the seed was sealed with 2.8 to 5.3 percent moisture and stored in a laboratory.

260. KINCAID, R. R. Tobacco seed storage for 25 years. Fla. Agr. Expt. Sta. Bul. 593, 10 pp. 1958.

Seed was stored in sealed and unsealed containers at room temperature and under refrigeration. Under room conditions unsealed seed deteriorated rapidly but under refrigeration it maintained viability for 15 years. Seed refrigerated in sealed containers maintained viability 25 years.

261. KJAER, A. Germination of buried and dry stored seeds. 1. 1934-1939. Internatl. Seed Testing Assoc. Proc. 12: 167-190. 1940. [In English. German summary, pp. 188-190.]

Seed of 37 crop and weed species were tested after 5 years' dry storage and compared to viability of the same species after being buried in the soil. Crop seeds from barley, wheat, ryegrass, timothy, orchardgrass, swede, turnip, red and white clovers, and yellow trefoil survived when stored dry but not when buried. Annual knawel and corncockle failed to survive either condition. All other species survived burying.

262. KJAER, A. Storage of Larix seeds. Internatl. Seed Testing Assoc. Proc. 16: 95-97. 1950.

This paper demonstrated that larch seeds could be stored for 7 years at room temperatures (Denmark) when sealed if they were previously dried to low moistures of 5.9 to 8.7 percent.

263. KOEHLER, B. Effect of prolonged storage of treated seed corn. (Abstract) Phytopathology 28: 13. 1938.

Viability of seed corn with 12 percent moisture treated with several mercurial compounds was not affected when stored for as long as 4 years in a warm building or an unheated warehouse. When storage was under the roof of an open shed, definite injurious effects were noted.

264. KOEHLER, B. Fungus growth in shelled corn as affected by moisture. Jour. Agr. Res. 56: 291-307. 1938.

Different humidities in stored corn were obtained by chemical means and a study was made of fungal development. Aspergillus developed at 14.3 percent moisture, whereas penicillium developed from 15.6 to 20.8 percent and fusarium from 18.4 to 21.2 percent. Diplodia, gibberella, and nigrospora developed at moisture contents of 21.5 to 23.0 percent.

265. KOEHLER, B. Effect of storage on yields of farm seed treated for disease control. Ill. Agr. Expt. Sta. Bul. 476, pp. 258-276. 1941.

Seeds of oats, barley, and corn were stored for 67, 35, and 78 to 91 days, respectively, after being treated with Ceresan and, for corn, other mercurial dusts. Higher yields for the small grains resulted from the treated seed as compared to the untreated. Yields of corn obtained by planting 1 year after treatment were as good as those obtained by planting a day after treatment.

266. KOEHLER, B. Hemp seed treatments in relation to different dosages and conditions of storage. Phytopathology 36: 937-942. 1946.

Seed deterioration of hemp seed over a 7-month period was rapid, even at 32° F., with moisture contents of 9.4 and 14.3 percent, the latter being more severe. When stored at 7.6 percent moisture, viability at 70° remained high when initial viability was high. Treatments with organic mercury fungicides were beneficial to stands, but more so when initial germination was low. New Improved Ceresan on seed with high moisture was somewhat injurious.

267. KOEHLER, B., and BEVER, W. M. Oat and wheat seed treatments: Methods, injuries, and gains. U. S. Agr. Res. Serv. Crops Res. Div., Plant Dis. Reporter 38: 762-768. 1954.

Wheat with approximately 12.5 percent moisture and treated with Ceresan at the rate of 1/4 ounce per bushel was uninjured after 150 days of storage in several kinds of containers. A loss of 4.4 percent in germination at a treatment rate of 1/2 ounce per bushel, and of 16.7 percent at a rate of 1-ounce, occurred when the grain was stored in sealed containers. No injury from Panogen at 3/4 ounce per bushel resulted in grain with average moisture contents from 11.4 to 13.9 percent.

268. KONDO, M. The storage of rice and change of its physical properties during this period. Ōhara Inst. f. Landw. Forsch. [Kurashiki, Japan] Ber. 3: [153]-175. 1926.

Hulled rice stored in straw bags lost its flavor and viability rapidly. With harvest in May viability was maintained until the following May, dropping to 60 to 80 percent germination in July, 11 to 30 percent in August, and finally, to less than 1 percent in October.

269. KONDO, M., and OKAMURA, T. On the effect of air-tight and carbon dioxide [storage] upon the storage of rice. Ōhara Inst. f. Landw. Forsch. [Kurashiki, Japan] Ber. 4: [1]-18. 1929.

Rice stored in straw bags for 2 years deteriorated to the extent that it could not be used as food. Both airtight and CO_2 storage preserved the rice in perfect condition, with CO_2 having a slight advantage.

270. KONDO, M., and OKAMURA, T. On the influences of various temperatures in duration of storage and various moistures of rice upon the preservation of germination power of hulled rice. Ōhara Inst. f. Landw. Forsch. Ber. 4: [315]-341. 1930.

Rice with a moisture content of no more than 12 percent maintained germination when storage was at granary temperatures.

271. KONDO, M., and OKAMURA, T. Germination power, analyses and vitamin-B of hulled rice stored during 4 years either air-tight or in carbon dioxide. Ōhara Inst. f. Landw. Forsch. Ber. 4: [343]-348. 1930.

Perfect germination resulted with rice stored 4 years, either airtight or in CO_2; no loss in protein, fat, or vitamin B occurred.

272. KONDO, M., and OKAMURA, T. Storage of rice. V. On the influence of a desiccating material upon the preservation of the germinating power of hulled rice having different moisture contents and stored at different temperatures. Ōhara Inst. f. Landw. Forsch. Ber. 5: [221]-242. 1931.

Germination of rice with 10 percent moisture could be maintained for a year at 40° C. when the grain was sealed with $CaCl_2$ as a desiccant. When sealed with $CaCl_2$ at 30° the grain maintained 12 and 14 percent germinability. When rice was stored with 16 percent moisture in either ventilated or airtight storage, viability was lost; but the grain was preserved at room temperatures with $CaCl_2$.

273. KONDO, M., and OKAMURA, T. Storage of rice. VI. Physical and biochemical studies of hulled rice stored in straw bags. Ōhara Inst. f. Landw. Forsch. Ber. 5: [395]-406. 1933. (Abstract in Chem. Abs. 27: 4284. 1933.)

Germination of rice was only 22 percent after 1.5 years storage in straw bags, and fell to 0.5 percent by the end of 2.5 years.

274. KONDO, M., and OKAMURA, T. Storage of rice. VIII. Studies on hulled rice stored air-tight 26 and 28 years. Ōhara Inst. f. Landw. Forsch. Ber. 5: [413]-420. 1933. (Abstract in Chem. Abs. 27: 4284. 1933.)

No chemical changes were found in rice after 26 to 28 years in airtight storage, but viability was completely lost.

275. KONDO, M., and OKAMURA, T. Storage of rice. X. Studies on four lots of unhulled rice stored forty-six to eighty-four years in granaries. Ōhara Inst. f. Landw. Forsch. Ber. 6: 175-185. 1934.

Although still edible, rice stored 46 to 84 years had lost viability.

276. KONDO, M., and OKAMURA, T. Storage of rice. XIII. Storage of rice in tin containers with calcium chloride, with special reference to the underdried product. II. Ōhara Inst. f. Landw. Forsch. Ber. 7: [99]-102. 1935.

The experiment reported was of 9 months' duration in which $CaCl_2$ reduced the moisture of rice from approximately 15.0 to 13.5 percent. Final germination of rice with 15.5 percent moisture was 18.5 percent, and 62.8 percent for rice with 14.8 percent moisture.

277. KONDO, M., and OKAMURA, T. Storage of rice. XVI. Storage of rice in concrete silos for five years. Ōhara Inst. f. Landw. Forsch. Ber. 7: [471]-481. 1937. (Abstract in Chem. Abs. 32: 5087. 1938.)

Both unhulled and hulled rice became brown when stored 5 years in small silos, but taste was not affected. Hulled grain stored better than unhulled with an economy in space.

278. KONDO, M., and OKAMURA, T. Storage of rice. XVIII. Relation between varying moisture content and change in quality of hulled rice, with special reference to the underdried product. Ōhara Inst. f. Landw. Forsch. [Kurashiki, Japan] Ber. 8: [11]-34. 1938.

The relationship between seed moisture and temperature was determined with regard to the deterioration of hulled rice. With 14 percent moisture, germination could be maintained for 2 years at 20° C., and for more than 2 years at 10° to 15°. To preserve seed with 16 percent moisture a storage temperature of 14° or below was required; for seed with 17 percent moisture, 10° or below; and for seed with 18 percent moisture, 5°.

279. KORSTIAN, C. F. Factors controlling germination and early survival in oaks. Yale Univ. School Forestry Bul. 19, 115 pp. 1927.

Only the overwinter storage of 6 oak species is involved. The results indicate that the best preservation was obtained with low temperatures, 33° to 38° F., and a high humidity.

280. KORSTIAN, C. F. Acorn storage in the southern states. Jour. Forestry 28: 858-863. 1930.

Germinations of three species tested after being stratified in moist sand and buried 3 feet from October to March are as follows: White oak 82.0, chestnut oak 85.3, and scarlet oak 85.7 percent. When acorns of two species were stratified in moist sand in cold storage (33° to 40° F.), the germinations were: Chestnut oak 80.3 and scarlet oak 90.7. Original germinations are not given.

281. KOSAR, W. F., and THOMPSON, R. C. Influence of storage humidity on dormancy and longevity of lettuce seed. Amer. Soc. Hort. Sci. Proc. 70: 273-276. 1957.

Lettuce seeds stored at a temperature of 10° C. were dead at the end of 1 year with relative humidity at 97 to 100 percent, at the end of 2 years at 88 percent, and after 4 years at 75 percent. The best viability was maintained with a relative humidity of 46 to 58 percent.

282. KREITLOW, K. W., and GARBER, R. J. Viability of stored seeds of forage crops treated with different fungicides. (Abstract) Phytopathology 36: 403. 1946.

Seeds of alfalfa, red clover, Ladino clover, and Sudan grass were treated with New Improved Ceresan, Semesan, Arasan, Spergon, and Yellow Cuprocide, and stored for 30 months in closed and open containers at 10° to 25° C. No injuries resulted from the treatments on the legumes at the higher temperature, and containers had no effect on viability. Injury of Sudan grass treated with New Improved Ceresan resulted in 1 month; in 6 months viability was lost. The other fungicides did not affect Sudan grass.

283. KRISHNASWAMY, P. Storage and germination of millet seeds. Madras Agr. Jour. 39: 485-490. 1952.

Eight varieties of millet, including the species of sorghum _Pennisetum_, _Eleusine_, _Setaria_, _Panicum_, _Echinochloa_, and _Paspalum_, were dried and stored in sealed bottles. Germination of 70 percent was maintained for 26 months for _Sorghum_ spp. to as high as 38 months for _Setaria_, _Panicum_, and _Echinochloa_. When seed was stored in gunny sacks, germination dropped to 4 to 38 percent in $1\frac{1}{2}$ years. Sun drying once a month did not materially improve keeping qualities.

284. KURUPP, N. K. B. Viability test with paddy variety, Cherunel. Presented at 28th Indian Sci. Cong., 1941. [From Biol. Abs. v. 16, No. 15356. 1942.]

Viability of Cherunel rice was maintained for 14 months in screw-top bottles, followed by a decline until complete loss of viability occurred in 22 months.

285. LAFFERTY, H. A. The loss of vitality in stored farm seeds. Ireland (Eire) Dept. Agr. Jour. 30: 237-245. 1931.

When stored under room conditions, seed of 11 crops dropped in germination the following amounts for the years of storage indicated: Oats 6 years, 48 percent; barley 4 years, 39 percent; perennial ryegrass 8 years, 66 percent; Italian ryegrass 11 years, 72 percent; meadow fescue 6 years, 52 percent; timothy 7 years, 68 percent; orchard grass 7 years, 68 percent; red clover 4 years, 77 percent; alsike clover 9 years, 72 percent; swede 8 years, 63 percent; and flax 10 years, 70 percent.

286. LAMBOU, M. G., CONDON, M. Z., and ALTSCHUL, A. M. New ideas on problems of storage. In Crops in war and peace, U. S. Dept. Agr. Yearbook of Agr. 1950-51: 551-557. 1951.

A review of work on the use of respiration and heating inhibitors. A large number of potential inhibitors are given.

287. LAMBOU, M. G., CONDON, M. Z., JENSEN, E., and others. A rapid method for the measurement of the inhibition of deterioration in intact seeds. Plant Physiol. 23: 84-97. 1948.

The heating of flax, sorghum, rice, and cottonseed was studied in relation to inhibitors, with ethylene chlorhydrin as a standard. Vinyl propionate at 0.23 percent was found to be as good an inhibitor as ethylene chlorhydrin over a period of 7 days.

288. LAMBOU, M. G., KING, G. S., and CONDON, M. Z. Effect of chemical treatment prior to storage on viability and growth of cottonseed. Science 108: 563-564. 1948.

When 4,6-bis-chloromethyl xylene in propylene glycol dipropionate were used in proportions of 1:8 as respiration inhibitor, the viability of cottonseed was higher and the free fatty acid content lower than for the control.

289. LAMBOU, M. G., PARKER, N. S., and CARNS, H. R. Effect of maleic hydrazide applied to the cotton plant on the development of free fatty acids in the seed. Amer. Oil Chem. Soc. Jour. 33: 199-202. 1956.

Maleic hydrazide was applied at two concentrations to cotton plants 16 days prior to and at defoliation time. Evidence indicated a suppression of free fatty acid formation in the field, reduction of mold proliferation in storage, and inhibition of the development of free fatty acids in the seeds. The treatments were effective for 16, 20, and 20 to 28 weeks at relative humidities of 100, 91, and 75 percent, respectively.

290. LaPINE, L. J., and MILBERG, E. A study of the effect of moisture on the longevity of imported Chewings fescue seed under laboratory and warehouse conditions. Assoc. Off. Seed Anal. Proc. 38: 62-65. 1948.

Records were kept on moisture and germination of Chewings fescue for 34 months. Moisture fluctuations were found to be detrimental to longevity. Two of three lots with over 11 percent moisture maintained high germination for 24 to 26 months.

291. LARMOUR, R. K., and BERSTEINSSON, H. N. The effect on wheat quality of long exposure to carbon tetrachloride. Canad. Jour. Res., Sect. C., Bot. Sci., 16: 241-247. 1938.

Samples of wheat in 5-pound lots were treated with carbon tetrachloride at 1-, 10-, and 20-cc. dosages. No damage occurred within 10 weeks with 18 percent moisture, but damage to quality was evident at 20 weeks. Wheat at 24 percent moisture kept well for 4 weeks without treatment, but damage occurred with 10- and 20-cc. treatments. All treatments were ineffective with wheat at 24 percent moisture after 4 weeks.

292. LARMOUR, R. K., CLAYTON, J. S., and WRENSHALL, C. L. A study of the respiration and heating of damp wheat. Canad. Jour. Res. 12: 627-645. 1935.

CO_2 evolution by respiring wheat with 20 percent moisture was 3 times as great with continuous aeration as with CO_2 not removed until the end of 23 hours. Toluene vapors reduced respiration after 6 days as compared with controls. Carbon tetrachloride reduced CO_2 evolution at moisture contents of 12 to 24 percent. Odors largely disappeared after aeration. Lowered evolution of CO_2 was attributed to control of fungi.

293. LARMOUR, R. K., SALLANS, H. R., and CRAIG, B. M. Hygroscopic equilibrium of sunflowerseed, flaxseed, and soybeans. Canad. Jour. Res., Sect. F., Technol., 22: 1-8. 1944.

At 25° C. and a relative humidity of 75 percent flaxseed had a moisture content of 10.3 percent, sunflowerseed 10.4, and soybeans 14.0. A period of 14 to 21 days was required for equilibria to become established.

294. LARMOUR, R. K., SALLANS, H. R., and CRAIG, B. M. Respiration of whole and dehulled sunflowerseed and of flaxseed. Canad. Jour. Res., Sect. F., Technol., 22: 9-18. 1944.

Respiration of flaxseed increased markedly above 12.8 percent moisture but was very low at 11.8 percent. Whole sunflowerseed was about equal in respiration rate at 9.9 and 10.8 percent moisture and had a slightly higher rate at 11.8 percent, but when at 12.8 had a much higher rate above these percentages. Respiration rates were higher for hulled sunflowerseed, with safe storage moisture estimated at 6 percent. For safe storage of whole seed the safe moisture content was estimated at 9.5 percent.

295. LATOUR, H. J. Notes on the storage of red pine seed for 9 years. N. Y. State Conserv. Dept., Notes on Forestry Invest. 38, p. 1. 1942.

The original germination of red pine seed was maintained for 9 years with 6 percent moisture in the seed when storage was in sealed carboys at 36° to 40° F.

296. LAUGHLAND, J., and LAUGHLAND, D. H. The effect of age on the vitality of soybean seed. Sci. Agr. 20: 236-237. 1939.

After 3 years of unspecified storage, field germination of soybeans at Guelph, Ont., dropped from 89.6 percent to 65.6 percent, and in 5 years to 8.0 percent. Viability was lost in 8 years.

297. LAWLOR, N., Jr., SWINK, J. F., JEWELL, H., and OGDEN, D. B. Results of seed treatment tests. Amer. Soc. Sugar Beet Technol. Jour. 9: [529]-535. 1957.

The most successful treatments for sugar beets in 20 months of storage were Orthocide at 4 and 12 ounces per 100 pounds of seed. There were no significant differences in germination of treated and untreated seeds. Field stands indicated a significant difference in favor of Orthocide.

298. LEACH, W. Studies on the metabolism of cereal grains. II. The effect of age and kernel size on the course of respiration of wheat during early germination stages. Canad. Jour. Res., Sect. C., Bot. Sci., 21: [289]-296. 1943.

Three varieties of wheat were stored for 6, 18, and 30 months and the rates of respiration studied. Based on weight of grain no differences in evolution of CO_2 were found. When kernel weights were compared, CO_2 evolution by the lighter kernels was somewhat higher than that by the heavier ones.

299. LEACH, W. Studies on the metabolism of cereal grains. III. The influence of atmospheric humidity and mould infection on the carbon dioxide output of wheat. Canad. Jour. Res., Sect. C, Bot. Sci., 22: 150-161. 1944.

Respiration rates of whole and degermed wheat were studied at high moisture levels. Degermed wheat respired more rapidly than whole, indicating that CO_2 output was due mostly to fungal respiration.

300. LEUKEL, R. W., and LIVINGSTON, J. E. Smut control in sorghum and effect of dust fungicides and storage on emergence. Phytopathology 35: 645-653. 1945.

In tests with 13 fungicides only sulfur resulted in a decrease in emergence after 180 days' storage. Slight injury was encountered with New Improved Ceresan and DuBay 1452-C. The other fungicides resulted in increased stands.

301. LEWIS, D. Seed storage. John Innes Hort. Inst. [London] Ann. Rpt. (1952) 43: 14-15. 1953.

After a 7-year period Primula sinensis seed sealed in CO_2 had a germination of 50 percent, but unsealed seed had completely lost viability. In 4 years, unsealed onion seed with an initial germination of 86 percent dropped to 25 percent germination; germination of the seed sealed in air dropped to 45 percent, that of seed sealed in CO_2 to 71 percent. Respective percentages for parsnip seed were 80; and 0, 37, and 40.

302. LINSTROM, E. W. Inheritance of seed longevity in maize inbreds and hybrids. Genetics 27: 154. 1942.

Germination tests on inbreds and F_1 crosses showed a variability from 0 to 9 percent germination after 5 to 12 years of storage. Crosses of short-lived and long-lived lines resulted in long-lived hybrids.

303. LOWE, A. E. Viability of buffalo grass seeds found in the walls of a sod house. Amer. Soc. Agron. Jour. 32: 891-893. 1940.

Seed of buffalo grass recovered from a sod house 25 years old germinated 28 percent.

304. LUTHRA, J. C. Ancient wheat and its viability. Current Sci. [India] 4: 489-490. 1936.

Tests on "mummy" wheat and barley showed them to be carbonized and to have no viability.

305. LYMAN, C. M., BURDA, E. J., and OLSCHNER, P. I. The effect of dielectric heating on storage quality of cottonseed. Amer. Oil Chem. Soc. Jour. 25: 246-249. 1948.

Dielectric heating raised the internal temperature of cottonseed to 100° C. in 1 minute. Water was removed rapidly with a 2- to 5-minute treatment, which reduced free fatty acid development in storage.

306. LYNES, F. F. Polyploidy in sugar beets induced by storage of treated seed. Amer. Soc. Agron. Jour. 37: 402-404. 1945.

Development of polyploids in sugar beet seed stored 1 to 2 years was greater when the seed was treated with 8 ounces of Improved Ceresan alone per 100 bushels than when it was so treated in combination with 8 ounces fume phosphate. Twice as many polyploids resulted from storing seed in burlap bags as compared to storing it in paper bags. Year-old seed had a range in polyploidy from 0 to 17.3 percent; the range for 2-year-old seed was 1.13 to 69.02 percent.

307. McALISTER, D. F. The effect of maturity on the viability and longevity of the seeds of western range and pasture grasses. Amer. Soc. Agron. Jour. 35: 442-453. 1943.

Several grasses harvested at premilk, milk, dough, and maturity stages were stored 58 months. Premilk and milk stages deteriorated more rapidly than others, except in the case of Bromus polyanthus. Stipa viridula increased in germination over the storage period. Mature seeds of stipa overcame dormancy in approximately 15 months.

308. McCOMB, A. L., and LOVESTEAD, H. S. Viability of cottonwood seeds in relation to storage temperatures and humidities. U. S. Forest Serv., Tree Planters' Notes No. 17, pp. 9-11. 1954.

By use of different combinations of temperature and humidity, it was determined that cottonwood seeds could be stored with only slight loss in viability for more than a year at 10° F. with humidity of 25 percent. Seeds kept well also at 41° and 25 percent relative humidity.

309. McHARGUE, J. S. The cause of deterioration and spoiling of corn and corn meal. Jour. Indus. and Engin. Chem. 12: 257-262. 1920.

Molds were found to develop on the grain when moisture content was 15 percent or above. At 20 percent moisture fermentation occurred. When corn spoiled, fat acidity increased threefold in the whole corn, slightly in the endosperm, and more than sixfold in the embryo.

310. McKEE, R., and MUSIL, A. F. Relation of temperature and moisture to longevity of seed of blue lupine, Lupinus angustifolius, Austrian Winter fieldpea, Pisum sativum [var.] arvense, and hairy vetch, Vicia villosa. Amer. Soc. Agron. Jour. 40: 459-465. 1948.

When stored at relative humidities of 80 to 95 percent, lupine and pea seeds absorbed moisture faster at 35° C. than at 20°, 25°, or 30°, the rate of absorption being directly proportional to temperature increases. At 35° storage and 80 to 95 percent humidity, lupine seed had a 78-percent loss in germination in 7 days, whereas peas were affected only slightly. Seeds of Austrian Winter peas and vetch with 15 percent moisture were nonviable at the end of 20 months when stored at 35°, but those stored at 20° had only slight deterioration.

311. MACMORRAN, A. M. Experimental seed storage. Roy, New Zeal. Inst. Hort. Jour. 15 (3): 24-25. 1946.

A preliminary report on a 10-year study of three indigenous species indicated that cold storage is superior to room storage.

312. MADSEN, S. B. Investigation of the influence of some storage conditions on the ability of seed to retain its germinating capacity. Internatl. Seed Testing Assoc. Proc. 22: 423-446. 1957.

When dried to approximately 4 percent moisture and placed in sealed bottles, red clover was preserved with almost unimpaired germination for 11 years, except that seed with low initial germination dropped more in this capacity than seed with high initial germination. Beet seed dried and sealed did not drop in germination in 11 years, without exception. Except for 2 samples seed of swede kept as well as beet seed. Cauliflower, brussels sprouts, and radish seeds lost germinability only slightly in 16 years under sealed conditions; when stored in paper bags they were worthless.

313. MALOWAN, J. Some observations on the heating of cottonseed. Cotton Oil Press 4 (11): 47-49. 1921.

High concentrations of acetic acid, ethanol, and formalin on cottonseed inhibited respiration. Respiration was not decreased when treatment was with $CuSO_4$ or $HgCl_2$. It was concluded that molds do not influence respiration in cottonseed.

314. MARRERO, J. A seed storage study of some tropical hardwoods. Caribbean Forester 4: 99-106. 1943. [In English. Spanish summary, p. 106.]

Seeds of Spanish cedar, Honduras mahogany, and algarroba were stored sealed and unsealed under room conditions in Puerto Rico (54° to 98° F. and 80 percent relative humidity) and under refrigeration storage (35° to 40°). At the end of 8 months' refrigeration, Spanish cedar with 46 percent initial germination had germinations of 20.5 and 22.5 percent in open and sealed containers, respectively. Under the same treatments for 1 year, Honduras mahogany with 54.5 percent initial germination had 14.5 and 21.0 percent germinations. Algarroba with the best keeping qualities had a drop from 52.0 to 43.0 percent in germination after 2 years for seed open in refrigerated storage, and from 58.0 to 28.5 percent for seed sealed under such storage.

315. MARTIN, J. A., SEENN, T. L., and CRAWFORD, J. H. Response of okra seed to moisture content and storage temperature. Amer. Soc. Hort. Sci. Proc. 75: 490-494. 1960.

Okra seeds with moisture contents from 8.0 to 25.0 percent were sealed in containers and stored for 10 years at room temperatures (70° to 100° F.) and in cold storage (35° to 40°). A moisture content of 12.0 percent was the upper limit for maintaining the seed for 10 years in cold storage, and a moisture content as low as 8.0 percent was required for maintaining high viability for 7 years at room temperatures.

316. MARTIN, J. N. Changes in the germination of red clover seed in storage. Iowa Acad. Sci. Proc. 51: 229-233. 1945.

Germination of red clover seed improved 12 to 14 percent after 6 months' storage in the laboratory.

317. MATHUR, P. B., PRASAD, M., and SINGH, K. Studies in the cold storage of peanuts. Jour. Sci. Food and Agr. 7: 354-360. 1956.

Peanuts were stored under four storage conditions over a 9-month period. They were found to have the highest viability when stored unshelled at 32° to 35° F. and a relative humidity of 85 to 90 percent. When stored at room temperatures (71° to 92°) and a relative humidity of 50 to 82 percent for 9 months, peanuts with 96 percent original germination germinated 64 percent for those stored shelled and 76 percent for those stored unshelled.

318. MATZ, S. A., and MILNER, M. Inhibition of respiration and preservation of damp wheat by means of organic chemicals. Cereal Chem. 28: 196-207. 1951.

Of 100 organic compounds tested, propylene oxide was the most effective in inhibiting respiration in wheat, but it was detrimental to seed viability. Carbon tetrachloride was effective provided the vapors were continuous; viability was not affected. Fatty acid development increased as moisture content of the seed was raised.

319. MILES, L. E. Effect of type and period of storage on cottonseed after treatment with organic mercuric dusts. Phytopathology 29: 986-991. 1939.

Storage of cottonseed either outdoors or in the laboratory in Mississippi for a 5-month period after treatment with organic mercury dusts had no effect on viability.

320. MILES, L. E. Effect of storage of treated cotton seed in closely woven cotton bags. (Abstract) Phytopathology 31: 768-769. 1941.

Cottonseed treated with Ceresan was uninjured by storage for 17 months in a cotton bag. New Improved Ceresan treatment increased emergence by 86.36 percent, and yields by 22.71 percent.

321. MILLER, P. M., and LINN, M. B. Viability of cabbage, carrot, sweet corn and lima bean seed treated with thiram or copper oxinate and stored at three different temperatures. U. S. Agr. Res. Serv. Crops Res. Div., Plant Dis. Reporter 41: 308-311. 1957.

Seeds of cabbage, sweet corn, and lima bean were treated with thiram and bioquin and stored 4, 8, and 12 months at 2° , 14°, and 32° C. Viability of the seeds was not affected by the treatments until after 12 months of storage.

322. MILLIGAN, R., and LINEHAN, P. A. Longevity of Lolium seed under commercial storage conditions. Internatl. Seed Testing Assoc. Proc. 22: 408-418. 1957.

In a test of 71 lots of Lolium perenne seed in commercial storage in Ireland, original germination for 23 samples averaged 85 percent. After 36 months of storage, the germination dropped to an average of 36 percent. Decline in germination was more rapid from 13 to 18 months to 36 months than it had been the first 13 to 18 months. Dried seed had about 20 percent better germination than undried fruit at the end of the 30- to 36-month storage period.

323. MILNER, M. The respiration and storage behavior of soybeans. 1945. [Unpublished doctor's thesis, Univ. of Minn.]

Apparent respiration of soybeans above 37° C. was attributed to nonbiological oxidation of organic compounds in the seeds.

324. MILNER, M. Utility of sulfa drugs for the inhibition of mold respiration in grain. Science 104: 463-464. 1946.

Sulfanilamide at a rate of 1 part to 2,000 parts of grain was effective in inhibiting mold growth and respiration in grain. It did not materially affect viability.

325. MILNER, M., CHRISTENSEN, C. M., and GEDDES, W. F. Grain storage studies. V. Chemical and microbiological studies on "sick" wheat. Cereal Chem. 24: 23-38. 1947.

Aspergillus spp. produced a marked reduction in germination of wheat. Sick symptoms developed in atmospheres of CO_2, N, or O_2 with 18 percent moisture in the wheat. Fat acidity increased most in O_2. Sick wheat was thought to be due not entirely to metabolic activity of molds.

326. MILNER, M., CHRISTENSEN, C. M., and GEDDES, W. F. Grain storage studies. VI. Wheat respiration in relation to moisture content, mold growth, chemical deterioration, and heating. Cereal Chem. 24: 182-199. 1947.

A study was made of the respiration rate of surface sterilized wheat at moisture contents from 12.3 to 38.6 percent. The rate of respiration was directly proportional to moisture content. There was a slight increase in the respiration quotient from 14.5 to 15.9 percent moisture. Inhibition of respiration by CO_2 was not pronounced until the concentration reached 12 percent.

327. MILNER, M., CHRISTENSEN, C. M., and GEDDES, W. F. Grain storage studies. VII. Influence of certain mold inhibitors on respiration of moist wheat. Cereal Chem. 24: 507-517. 1947.

Thiourea at the rate of 1.0 percent inhibited mold growth on wheat and had a low toxicity. Also, 8-hydroxyquinoline sulfate was a good inhibitor but somewhat toxic. Respiration in these treatments remained constant over a 10-day period.

328. MILNER, M., and GEDDES, W. F. Grain storage studies. II. The effect of aeration, temperature, and time on respiration of soybeans containing excessive moisture. Cereal Chem. 22: 484-501. 1945.

In studying the rate of respiration over a temperature range of 25° to 45° C. the maximum evolution of CO_2 was obtained at 40°, the minimum at 45°. CO_2 evolution increased with increase in change of air up to 1,500 ml. per 24 hours.

329. MILNER, M., and GEDDES, W. F. Grain storage studies. III. The relation between moisture content, mold growth, and respiration of soybeans. Cereal Chem. 23: 225-247. 1946.

The respiration rate of soybeans under aeration at 37.8° C. with 14 percent or less moisture remained relatively constant over an 11-day period, whereas with beans having 14.6 percent moisture the rate increased sharply after 4 days. In artificially moistened soybeans the respiration rate did not increase in a period of 11 days unless the moisture content was 18.3 percent. Severely damaged beans increased in respiration rate when moisture contents were at and above 16.1 percent. The viability of soybeans was adversely affected by a temperature of 37.8°, and more so where moisture contents favored mold growth.

330. MILNER, M., and GEDDES, W. F. Grain storage studies. IV. Biological and chemical factors involved in the spontaneous heating of soybeans. Cereal Chem. 23: 449-470. 1946.

A study of heating and respiration of soybeans over a 37-day period under adiabatic aerated conditions. Initial temperature rise under moistures favoring mold proliferation was attributed to mold growth. In sterile seed, disappearance of total sugars was observed.

331. MILNER, M., MITCHELL, H. L., GOODING, J. A., and LAUDE, H. H. Preliminary study of the influence of certain commercial and laboratory preservatives on the deterioration of damp sorghum grain and alfalfa hay. Kans. Agr. Expt. Sta. Prog. Rpt. 6, [11] pp. 1951.

Thiourea at 40 pounds per ton of grain sorghum at 20 percent moisture content and a mixture of propylene oxide and carbon tetrachloride (1-1) at 8 pounds per ton completely inhibited in 9 days the respiration in the grain attributable to fungal infection.

332. MILTHORPE, J., and ROBERTSON, R. N. Heating in stored wheat. I. Respiration of dry grain, insect respiration, and temperature and moisture effects. Austral. Council Sci. and Indus. Res., Bul. 237, pp. [9]-17. 1948.

Wheat of 10.8 percent moisture lost viability in 30 days at 60° C., having dropped to about 6.5 percent of initial germination in 15 days. Viability was retained at 30° and 40°. The bulk of CO_2 evolution in grain with moisture contents between 8.8 and 11.1 percent was due to insect respiration.

333. MIROV, N. T. Storage and germination of California cork-oak acorns. U. S. Forest Serv. Calif. Forest and Range Expt. Sta. [Berkeley], Forest Res. Notes No. 36, 18 pp. 1943.

Experiments showed that cork-oak acorns, stored with or without sand in sealed 5-gallon cans at 32° F., maintained their original germination for 24 weeks. Those sealed with sand had lost only 12 percent of initial germination at the end of 32 weeks.

334. MIROV, N. T. Viability of pine seed after prolonged cold storage. Jour. Forestry 44: 193-195. 1946.

Various species of conifer seeds stored at 40° F. in 5-gallon cans retained their viability for 15 years. *Pinus aristata*, *P. attenuata*, *P. contorta bolanderi*, *P. lambertiana* ranged in germination from 86 to 94 percent after 9 to 14 years.

335. MORRISON, G. Life span of seed. Seed World 50 (2): 8-9. 1941.

A review of longevity studies by Ewart, Ohga, and Beal. These studies are covered by reference numbers 161, 356, and 126, respectively.

336. MOSS, E. H. Longevity of seed and establishment of seedlings in species of *Populus*. Bot. Gaz. 99: 529-542. 1938.

At room temperatures seed of poplars deteriorated in 4 weeks at humidities from 0 to 90 percent. The best relative humidity for prolonging longevity was 10 percent. The viability of seed that was dried and stored at -5° C. was preserved for 2 years.

337. MOUTIA, L. A., and MAMET, R. Experiments on the storage of maize seeds. Rev. Agr. de l'Ile Maurice 22: 5-9. 1943.

A short-term experiment with various preservatives is reported. Naphthalene proved to be effective in preventing insect infestation and mold infection; when it was used in sealed cans the germination of corn following 7 months' storage was superior to that of nontreated controls. Treated seed in 7 months lost only 15 percent in germinability as compared to a loss of 31 percent in the controls.

338. MUENSCHER, W. C. Storage and germination of seeds of aquatic plants. N. Y. (Cornell Univ.) Agr. Expt. Sta. Bul. 652, 17 pp. 1936.

Aquatic plants of 43 species stored in water at 1° to 3° C. proved most successful over a 7-month period. Germination failed or was poor when the seeds were stored in water at room temperature unless they were prechilled for 30 days. Germination was lost in dry storage regardless of temperature.

339. MUENSCHER, W. C., and BROWN, B. I. Storage and germination of nuts of several species of Juglans. North. Nut Growers Assoc. Ann. Rpt. (1943) 34: 61-62. [1944.]

Ten species of Juglans stratified for 5 to 6 months in moist peat maintained high viability. Field germination among the various species ranged from 18 to 92 percent.

340. MYERS, A. Longevity of seed of native grasses. Agr. Gaz. N. S. Wales 51: 405. 1940.

Under laboratory storage the germination of Panicum antidotale dropped from 16 to 3 percent in 12 years; that of P. decompositum over a 10-year period rose from 2 to 63 percent and dropped to 3 percent; P. prolutum dropped from 48 percent to 2 percent in 9 years. Paspalidium jubiflorum with initial germination of 43 percent rose to 72 and dropped to 1 percent in 10 years. Danthonia semiannularis rose in germination from 22 to 100 percent and dropped to 5 percent in 7 years.

341. MYERS, A. Effect of naphthalene on stored lucerne seed. Agr. Gaz. N. S. Wales 53: 570. 1942.

Viability of lucerne seed was maintained for 1 year when the seed was treated with naphthalene at the rate of 1 or 2 ounces per bushel.

342. MYERS, A. Germination of stored lucerne seed. Agr. Gaz. N. S. Wales 63: 284-285. 1952.

Sealed seed of lucerne maintained high viability for 4 years when stored under dry, subtropical, or temperate climates. Under subtropical conditions, deterioration of unsealed seed was rapid.

343. MYERS, A. Viability of strawberry seed. Agr. Gaz. N. S. Wales 65: 31. 1954.

Strawberry seed was stored for 2 years at Sidney and also at Bathurst, where the humidity is higher and the temperature lower than at Sidney. The seed remained viable at both locations, but germination of the seed stored at Bathurst was higher.

344. NAGEL, C. M., and SEMENIUK, G. Some mold-induced changes in shelled corn. Plant Physiol. 22: 20-33. 1947.

An increase in fat acidity in stored corn was attributed to lipase activity of fungi.

345. NAVASHIN, M. Origin of spontaneous mutations. Nature [London] 131: 436. 1933.

Fresh seed of Crepis tectorum displayed 0.1 percent spontaneous dislocations. Of 27 seeds that produced plants after 7 years' storage, 80 percent showed chromosomal mutations of various types, including chimeras, inversions, and translocations.

346. NAVASHIN, M., GERASSIMOVA, H., and BELAJEVA, G. M. On the course of the process of mutation in the cells of the dormant embryo within the seed. Acad. des Sci. de l'URSS Compt. Rend. (Dok.) 26: 948-951. 1940.

Seed of Crepis capillaris stored in a basement and subject to fluctuating temperature and humidity lost viability in a straight line relationship over a period of 5 years, whereas the percentage of mutations rose sharply after 3 years. Percentages of mutation occurring in 2 to 5 years were: 1.5 percent at 2 years, 3.6 at 3, 17.7 at 4, and 30.5 at 5.

347. NAVASHIN, M., and SHKVARNIKOV, P. K. Process of mutation in resting seeds accelerated by increased temperature. Nature [London] 132: 482-483. 1933.

The mutation rate in Crepis tectorum resulting from a 20-day heat treatment of 54° to 55° C. was equal to the rate obtained from an X-ray dosage of 15,000 r., also equivalent to that obtained when the seed was stored at room temperature for 6 to 7 years.

348. NEAL, N. P., and DAVIS, J. R. Seed viability of corn inbred lines as influenced by age and conditions of storage. Agron. Jour. 48: 383-384. 1956.

When a number of inbred lines of corn were stored during periods of 1 to 9 years, marked differences in the longevity of the inbreds were noted. Reactions to the "cold test" were better when the seed was stored relatively airtight at 40° F. than when stored in bags at prevailing room temperature.

349. NELSON, M. L. Successful storage of southern pine seed for seven years. Jour. Forestry 38: 443-444. 1940.

The initial viabilities of slash, long-leaf, loblolly, and short-leaf pine seeds were maintained for 7 years of storage in sealed containers at 35° to 38° F. None survived when stored at room temperatures.

350. NESTLER, R. B. Germination of seeds of some wild and cultivated plants after 5½ years of storage. Jour. Forestry 44: 683-684. 1946.

In this experiment at Bowie, Md., storage tests were conducted under room conditions for about 6 months, followed by 32° to 33° F. for 2 years, then by 0° for 2 years. Of 33 species, 15 failed to germinate, and then only Robinia pseudoacacia, Strophostyles helvola, and Vicia angustifolia had a germination of 70 percent or better.

351. NICHOLS, C., [Jr.] Spontaneous chromosome aberrations in Allium. Genetics 26: [89]-100. 1941.

The percent of chromosomal aberrations from storing seed of Yellow Strassburg onion increased from 1.6 at 1 to 2 years' storage to 7.5 at the end of 4 to 5 years, that of Ohio Yellow Globe from 1.6 at 2 to 3 years to 3.1 at 3 to 4 years. In Sweet Spanish there were 2.4 percent aberrations at the end of 1 year of storage, and 12.7 percent in 3 to 4 years. The increases in the frequencies of aberration were greater than the corresponding decreases in germination.

352. NICHOLS, C., Jr. The effects of age and irradiation on chromosomal aberrations in Allium seed. Amer. Jour. Bot. 29: 755-759. 1942.

A greater number of aberrations were found in irradiated onion seed 1 to 5 years old than in irradiated fresh seed. Delayed germination further increased the aberration rate in older seed, whereas fresh seed was not affected.

353. NOYES, G. B. Storage of tea seed. Ceylon Tea Res. Inst. Tea Quart. 28: 55. 1957.

This is a note of 8 lines concerning the satisfactory storage of tea seed in wooden boxes at 40° F. for 6 months.

354. OATHAUT, C. H. The vitality of soybean seeds as affected by storage conditions and mechanical injury. Amer. Soc. Agron. Jour. 20: 837-855. 1928.

A moisture content of 10 to 14 percent in soybeans was satisfactory for storage if ventilation was provided. When moisture was above 14 percent, heat in addition to ventilation was necessary.

355. O'CONNELL, T. Storage and treatment of seed wheat. Ireland (Eire) Dept. Agr. Jour. 39: 224-229. 1942.

This paper consists of a rewrite from a radio broadcast of general nature and contains no experimental data.

356. OHGA, I. The germination of century-old and recently harvested Indian lotus fruits, with special reference to the effect of oxygen supply. Amer. Jour. Bot. 13: 754-759. 1926.

After scarification with sulfuric acid, 200-year-old lotus seed germinated 100 percent. A sufficient amount of oxygen was internally contained to allow germination without an external supply. The old seeds produced longer sprouts than the fresh seeds.

357. OLAFSON, J. H., CHRISTENSEN, C. M., and GEDDES, W. F. Grain storage studies. XV. Influence of moisture content, commercial grade, and maturity on the respiration and chemical deterioration of corn. Cereal Chem. 31: 333-340. 1954.

Respiration in stored corn increased in proportion to an increase of moisture content from 12.9 to 17.0 percent, and in proportion to the drop in the commercial grade from No. 1 to No. 5. An increase in reducing sugars and fat acidity and a decrease in nonreducing sugars were associated with length of storage.

358. OOSTING, H. J., and HUMPHREYS, M. E. Buried viable [weed] seeds in a successional series of old field and forest soils. Torrey Bot. Club Bul. 67: 253-273. 1940.

Seeds of some weed species remained viable after 200 years in the soil of an oak-hickory woods.

359. OWEN, E. B. The storage of seeds for maintenance of viability. Commonwealth Bur. Pastures and Field Crops [Hurley, Berkshire, England] Bul. 43, 81 pp. [1956].

A well documented bulletin of 10 chapters covering longevity of seed, hygroscopicity, drying, changes in composition during storage, dormancy, and treatment in relation to storage.

360. OXLEY, T. A. The reduction of losses in grain by control of water content. In Preservation of grains in storage, F.A.O., U.N., Agr. Studies No. 2, pp. 92-99. 1948.

The drying of grain in relation to satisfactory storage moistures is discussed in a popular manner.

361. OXLEY, T. A. The storage and drying of cereal seeds. Natl. Inst. Agr. Bot., Jour. 5: [465] -482. 1950.

General instructions are given for drying and storing of grain. No experimental work is involved, but attention is called to a heat limitation of 120° F. for grain with 24 percent moisture, and of 110° for grain with moisture above 24 percent.

362. OXLEY, T. A., and JONES, J. D. Apparent respiration of wheat grains and its relation to a fungal mycelium beneath the epidermis. Nature [London] 154: 826-827. 1944.

Removal of wheat pericarps lowered CO_2 output to 5 percent of that of intact wheat. High CO_2 output was attributed to micro-organisms growing in the pericarp or bran.

363. PACK, D. A., and OWEN, F. V. Viability of sugar beet seed held in cold storage for 22 years. Amer. Soc. Sugar Beet Technol. Proc. 6: [127]-129. 1950.

Sugar beet seed held at -10° to 10° F. for 22 years germinated only 10 percent less than when placed in storage. No reduction in vigor resulted from storage.

364. PADMANABHAN, S. Y. Preserving viability of rice seeds with fungicides. Indian Phytopath. 9: [44]-47. 1956.

Of the fungicides tested to preserve rice seed during the monsoon season (July-Oct.) Cuprocide at the rate of 1/500 seed weight was the most effective. Thin long-grained varieties lost viability rapidly as compared to little loss of other types.

365. PAP, L. Hygroscopicity of wheat. Cereal Chem. 8: 200-206. 1931.

Samples of wheat from numerous countries were taken for hygroscopicity. At 65.3 percent relative humidity moisture contents ranged from 12.1 to 12.9 percent.

366. PAPAVIZAS, G. C., and CHRISTENSEN, C. M. Grain storage studies. XXV. Effect of Invasion of storage fungi upon germinations of wheat seed and upon development of sick wheat. Cereal Chem. 34: 350-359. 1957.

Wheat, both sterile and inoculated with Aspergillus spp., was stored for periods up to 12 weeks. Low germination was always associated with fungal infection, most of the injury occurring at higher seed moistures and storage humidities. A. restrictus caused the most damage.

367. PAPAVIZAS, G. C., and CHRISTENSEN, C. M. Grain storage studies. XXVI. Fungus invasion and deterioration of wheats stored at low temperatures and moisture contents of 15 to 18 per cent. Cereal Chem. 35: 27-34. 1958.

White wheat with 15.0 to 15.5 percent moisture inoculated with storage fungi and stored 12 months at either 5° or 10° C. had no decrease in viability; when the wheat had 16.0 to 16.5 percent moisture, the fungal invasion was severe. With 16.0 to 18.0 percent moisture at a storage temperature of -5°, viability remained high and no fungal invasion occurred; however, at 5° and 10° both loss of viability and fungal invasion resulted. Uninoculated wheat that remained free of fungi stayed highly viable. Indications were that wheat of 16.0 percent moisture can be stored at 10° for i year, of 18.0 percent moisture at -5° for 19 months.

368. PAPAVIZAS, G. C., and CHRISTENSEN, C. M. Grain storage studies, XXIX. Effect of invasion by individual species and mixtures of species of Aspergillus upon germination and development of discolored germs in wheat. Cereal Chem. 37: 197-203. 1960.

Samples of hard red spring wheat were surface-disinfected and inoculated with spores of Aspergillus amstelodami, A. ruber, A. restrictus, and A. candidus, alone and in combinations. The samples were stored at 25° C. and at relative humidities of 75, 80, and 85 percent with moisture contents of 14.7 to 14.9 percent, 16.0 to 16.4 percent, and 17.0 to 17.2 percent, respectively. After 1 to 5 months they were tested for germination, discolored germs, and numbers and kinds of fungi. Inoculation with mixtures of species did not result in a greater loss of germination or development of more germ damage than did inoculation with the most pathogenic species alone. Samples of durum, hard red spring, hard red winter, and white wheats were inoculated with spores of A. amstelodami and A. candidus, stored 3 months at 25° and 80 percent relative humidity, and similarly tested. Damage, as evaluated by reduction in germination and increase in discolored germs, was greater in the hard red winter and white wheats than in the durum and hard red spring wheats. The noninoculated controls in all tests remained free or almost free of fungi, retained a high germination percentage, and developed little or no germ damage.

369. PASFIELD, D. H. Confined atmosphere storage of grain. Farm Mechanization 5: 16-17. 1953.

No experimental work is involved in the study. The article discusses the advantages and disadvantages of hermetic storage of grain.

370. PATIL, N. A. Germination of stored tobacco seed. Indian Tobacco 5: 23-24. 1955.

Seeds of four varieties of tobacco germinated 83 percent or more after 3 years' storage in airtight containers. Germination of bidi tobacco was negligible in the fifth year. Harrison and Bonanza varieties dropped to 8 and 7 percent germination, respectively, in the fifth year.

371. PATON, R. R. Storage of tuliptree seed. Jour. Forestry 43: 764-765. 1945.

Seed of the tuliptree stored in pits with alternating layers of sand at Marietta, Ohio, had 15 percent germination after 4 years.

372. PETERSON, A., SCHLEGEL, V., HUMMEL, B., and others. Grain storage studies. XXII. Influence of oxygen and carbon dioxide concentrations on mold growth and grain deterioration. Cereal Chem. 33: 53-66. 1956.

Sound wheat with 18 percent moisture was stored in atmospheres of different amounts of oxygen and carbon dioxide. The respiration, mold growth, germ damage, and fat acidity decreased as the oxygen was lowered from 21.0 to 0.2 percent; at the lower oxygen levels viability was maintained. With 21.0 percent oxygen, the carbon dioxide level had little effect on respiration until the CO_2 percentage reached 13.8 to 18.6. A sharp increase in fat acidity and a decrease in mold growth followed increases in carbon dioxide percentages in the atmosphere.

373. PETO, F. H. The effect of aging and heat on the chromosomal mutation rates in maize and barley. Canad. Jour. Res. 9: 261-264. 1933.

Corn 5 years old had a mutation rate of 4 percent; corn 6 years old a rate of 8 percent. Heating barley seed to 95° C. produced 27 percent mutated cells in the seminal roots and 9 percent in the root tips.

374. PHILLIS, E., and MASON, T. G. The effect of extreme desiccation on the viability of cotton seed. Ann. Bot. [London] 9: 353-359. 1945.

Cottonseed stored for 5 years under 20 percent relative humidity at a temperature of 75 to 85 F. dropped in germination from 90 to 65 percent. At 30 percent relative humidity the germination dropped to 70 percent, at 40 percent humidity the germination dropped to 75 percent. Deterioration was rapid when the relative humidity was lowered to 0 percent.

375. PRITCHARD, E. W. How long do seeds retain their germinating power. Longevity experiments in the Department of Agriculture. So. Austral. Dept. Agr. Jour. 36: 645-646. 1933.

Among 52 crop seeds stored 6 years, the best in longevity were bean, parsnip, pea, pumpkin, tomato, and Wattle Cootamundra; subclover and radish were intermediate. Poor keepers were beet, cabbage, carrot, clover (crimson, white, and red), trefoil, cucumber, lettuce, onion, spinach, turnip, rock melon, and watermelon. Storage conditions were not given, but storage was probably in a laboratory.

376. PUGSLEY, H. W. The longevity of seeds. Jour. Bot. 66: 203-204. 1928.

This article consists of observations on the longevity of certain seeds in the soil. Cytisus scoparius grew after being buried 25 years.

377. PYKE, E. E., LEONARD, E. R., and WARDLAW, C. W. On the viability of cacao seeds after storage. Trop. Agr. [Trinidad] 11: 303-307. 1934.

Storage of cacao seeds in the pod, involving a maximum of 50 days, showed that with a prior treatment of the seed pods with mercuric chloride and coating them with vaseline the best storage temperature was between 60° and 70° F.

378. RADKO, A. M. Zoysia seed storage and germination tests. U. S. Golf Assoc. Jour. 8 (6): 25-26. 1955.

Seed of Zoysia japonica when stored sealed and unsealed at 5°, 15° and 25° C., the sealed containers containing 9 gr. $CaCl_2$ per liter of space, dropped markedly in germination after $2\frac{1}{2}$ years. Storage temperature at 5° appeared to be better than at 15° or 25°, except when sealed with calcium chloride.

379. RAMSTAD, P. E., and GEDDES, W. F. The relative respiratory rates and hygroscopic equilibria of common and hull-less oats. Jour. Agr. Res. 64: 237-241. 1942.

Hull-less oats had a lower respiration rate than common oats. It was concluded that oats without hulls would store as well as common oats.

380. RAMSTAD, P. E., and GEDDES, W. F. The respiration and storage behavior of soybeans. Minn. Agr. Expt. Sta. Tech. Bul. 156, 54 pp. 1942.

When soybeans with over 15 percent moisture were stored, an increase in nonreducing sugars and a decrease in reducing sugars were observed. The respiration rate and mold growth increased with time of storage.

381. RAO, V. N. M., RAO, I. K. S., and HASSAN, M. V. Studies on viability in cashew. Indian Jour. Agr. Sci. 27: 289-294. 1957.

Cashew nuts stored with 100 percent germination in unsealed tin cans, in sealed tin cans, and wrapped in 100-gage alkathene film in tin cans had, at the end of 12 months, germination percentages of 96.4, 97.9, and 94.6 percent, respectively. Nuts stored in either gunny or straw bags were practically worthless for planting purposes after 6 or 7 months.

382. ROBBINS, W. A., and PORTER, R. H. Germinability of sorghum and soybean seed exposed to low temperatures. Amer. Soc. Agron. Jour. 38: 905-913. 1946.

Freshly harvested seeds of sorghum and soybeans with various amounts of moisture were subjected to temperatures of 33°, 20°, and -20° F., for 8 and 12 hours in the case of sorghum and 10 hours in the case of soybeans. At -20° all varieties of sorghum were killed in 12 hours, except Black Amber, which had a final germination of 7 percent as compared to 88 percent for the check. With moisture contents of 30 to 32 percent or less, soybeans were uninjured in 10 hours by -20° temperature; with 50 to 60 percent moistures, most varieties received no injury at 20°.

383. ROBERTSON, D. W., and LUTE, A. M. Germination of seed of farm crops in Colorado after storage for various periods of years. Amer. Soc. Agron. Jour. 29: 822-834. 1937.

Storage for 10 years under prevailing weather conditions in Colorado caused the germination of wheat, barley, and oat seeds to drop 7, 14, and 13 percent, respectively. Rosen rye and Wisconsin Black soybeans dropped 10 percent in germination in 5 years. The drop for Black Amber sorghum was 2 percent in 6 years, that for Yellow Dent corn 20 percent in 8 years.

384. ROBERTSON, D. W., LUTE, A. M., and GARDNER, R. Effect of relative humidity on viability, moisture content, and respiration of wheat, oats, and barley seed in storage. Jour. Agr. Res. 59: 281-291. 1939.

At 75 percent relative humidity and 70° F., wheat had 15 percent moisture. Wheat, oats, and barley treated with organic mercury compounds had a greater loss of viability during storage than the untreated lots; the treatment injury was more pronounced above 74°.

385. ROBERTSON, D. W., LUTE, A. M., and KROEGER, H. Germination of 20-year-old wheat, oats, barley, corn, rye, sorghum, and soybeans. Amer. Soc. Agron. Jour. 35: 786-795. 1943.

Soybeans and rye were nonviable after 15 years of storage in an unheated room at Ft. Collins, Colo. Corn dropped gradually in 21 years to 32 percent of initial germination; sorghum lost little viability in 15 years, but thereafter the drop was rapid. Over a 10-year period there was a slow decline in the germinability of oats, barley, and wheat, followed by a sharp drop in the next 11 or 12 years to about 50 percent for oats, 42 percent for barley, and 13 percent for wheat.

386. ROCHA, F. F. Interaction of moisture content and temperature on onion seed viability. Amer. Soc. Hort. Sci. Proc. 73: 385-389. 1959.

Onion seed with moisture contents of 6.5 to 15.7 percent at temperatures of 30° to 60° C. suffered no injury. When the seed had moisture contents between 6.5 and 9.2 percent, storage for 104 days at 25° produced very little loss in viability. There was a slight loss at 11.0 percent moisture, and a rapid decline when the moisture percentage was between 13.0 and 15.0.

387. RODRIGO, P. A. Longevity of some farm crop seeds. Philippine Jour. Agr. 6: 343-357. 1935.

Rice, corn, mung beans, cowpeas, and tapilan were stored in sealed containers with and without naphthalene, and in cloth bags. In cloth bags all but black tapilan were dead after 9 to 10 months' storage. When seed was sealed, with or without naphthalene, rice and corn had high viability for 4 years followed by a rapid decline. Mung beans held up for 9 years sealed with naphthalene and 11 years without. Cowpeas stored equally well with and without naphthalene for 8 years. The germination of white tapilan, with sealing, gradually dropped over a 10-year period, but the black variety retained its original viability.

388. RODRIGO, P. A. Study on the vitality of old and new seeds of mungo (Phaseolus aureus Roxb.). Philippine Jour. Agr. 10: 285-291. 1939.

Mung beans after 11 years' storage produced significantly higher yields of pods and beans than fresh seed.

389. RODRIGO, P. A. Some studies on the storing of tropical and temperate seeds in the Philippines. Internatl. Hort. Cong. Rpt., London (1952), 13: 1061-1066. [1953.]

When seed was stored in sealed containers at 78.6° F., the lengths of life for the seeds of the species involved were as follows, in months: Lettuce, 27; cabbage and peanuts, 37; cucumber and onion, 38; radish, 39; cauliflower, 46; asparagus, 50; eggplant, 53; soybean, 55; pepper, 65; pechay, 66; corn, 59 to 82; rice, 82 to 88; cowpea, 123; yellow tapilan, 138; and mung bean and black tapilan, over 201.

390. ROE, E. I. Longevity of red pine seed. Minn. Acad. Sci. Proc. 8: 28-30. 1940.

Seed samples of red pine (Pinus resinosa) after 10 years of sealed storage at 32° to 39° F. and with moisture contents of 4.7 and 6.5 percent germinated 97.5 and 97.0 percent, respectively. With a temperature range of 0° to 100°, the germinations for the two moisture contents were respectively 46.2 and 26.4.

391. ROE, E. I. Viability of white pine seed after 10 years of storage. Jour. Forestry 46: 900-902. 1948.

White pine seed with 5.6 to 7.3 percent moisture and an initial germination of 50 percent (with a probable higher percentage of viability) was stored in sealed containers. After 8 years of storage at 32° to 39° F., seed that had a final moisture content of 8.2 percent had 86 percent germination and those with 7.8 percent moisture, 93 percent.

392. RUDOLF, P. O. Low temperature seed storage for western conifers. U. S. Forest Serv. Lake States Forest Expt. Sta., Misc. Rpt. 20, 8 pp. 1952.

This article contains no research data, but reviews the general requirements for the storage of coniferous seeds.

393. RUSCA, R. A., and GERDES, F. L. Effects of artifically drying seed cotton on certain quality elements of cottonseed in storage. U. S. Dept. Agr. Cir. 651, 19 pp. 1942.

When stored for 90 days after drying for 15 seconds at 160°, 190°, and 220° F., cottonseed with moistures below 12 percent had an average germination of 86 percent immediately after each of the heat treatments, and of 94 percent after 90 days. A moisture content above 12 percent resulted in an average 8-percent drop in germination.

394. RYAN, G. F. Albinism in citrus seedlings. Calif. Agr. Expt. Sta., Calif. Agr. 12 (3): 7, 12. 1958.

Lowered viability of seeds of Cleopatra mandarin was observed in 1 month after treatment with 8-hydroxyquinoline. Arasan had a beneficial effect over a 12-month storage period.

395. SAHADEVAN, P. C. Studies on the problem of loss of viability of rice seeds in storage. Madras Agr. Jour. 40: [133]-143. 1953.

This paper covers experiments relating to the maintenance of the viability of rice during the humid monsoon season. High germination was maintained with any method providing for the exclusion of air during storage.

396. SAHADEVAN, P. C., and NARASINGA RAO, M. B. V. Note on the deterioration in germination-capacity of a paddy strain in Malabar and South Kanara. Current Sci. [India] 16: 319-320. 1947.

This study considers storage of rice seed only from harvest to following planting date, wherein the seeds stored in sealed containers remained viable but those in open containers did not. Soaking seed in water followed by moderate drying apparently prolongs the period through which they may be successfully stored.

397. SALLANS, H. R., SINCLAIR, G. D., and LARMOUR, R. K. The spontaneous heating of flaxseed and sunflower seed stored under adiabatic conditions. Canad. Jour. Res., Sect. F., Technol., 22: 181-190. 1944.

Heating of flaxseed and sunflowerseed in storage was attributed to fungal invasion rather than seed respiration. Maximum safe moisture contents for storage of flaxseed and sunflowerseed were found to be 10.5 and 9.5 percent, respectively.

398. SAN PEDRO, A. V. Influence of temperature and moisture on the viability of some vegetable seeds. Philippine Agr. 24: 649-658. 1936.

Temperature had little effect on longevity of vegetable seed stored over $CaCl_2$. In the absence of a drying agent all but lettuce kept well for 162 days. After 312 days, marked deterioration was noted in bean, eggplant, pechay, lettuce, and tomato seeds. Deterioration was progressive as temperatures were increased from 0° to 28° C.

399. SAUNDERS, C. E. (Dominion Cerealist). Effect of storage on wheat and flour. In Canada Expt. Farms Ann. Rpts., Rpt. Cerealist, 1908-9: 205-206. 1909.

A brief summary to the effect that proper storage improves the quality of wheat and flour.

400. SAUNDERS, C. E. (Dominion Cerealist). Effect of storage on wheat and flour. In Canada Expt. Farms Ann. Rpts., Rpt. Cerealist, 1909-10: 168. 1910.

A reiteration of work covered under reference number 399.

401. SAYRE, J. D. Storage tests with seed corn. Ohio Jour. Sci. 40: 181-185. 1940.

Seed corn with 18 percent moisture stored in sealed tubes remained viable for 6 years at below freezing temperatures but lost all its viability at approximately 30° C. The seed stored in oxygen at 30° died in 3 years; a noticeable drop in germination was evident when the seed was stored either in carbon dioxide or in nitrogen. At low temperatures the seed in carbon dioxide and in nitrogen had good germination for 5 years.

402. SCHWENDIMAN, J. L., and MULLEN, L. A. Effects of processing on germinative capacity of seed of tall oatgrass, Arrhenatherum elatius (L.) Mert. and Koch.* Amer. Soc. Agron. Jour. 36: 783-785. 1944.

After 4 years of storage in a dry, unheated room at Pullman, Wash., seed of tall oatgrass processed by milling once, milling twice, and dehulling completely germinated 85.5, 74.5, and 67.0, respectively, as compared to 88.5 percent for the check seed.

403. SEMENIUK, G., and GILLMAN, J. C. Relation of molds to deterioration of corn in storage, a review. Iowa Acad. Sci. Proc. 51: 265-280. 1944.

A review of literature covering mostly fungal infection of stored corn. A 12 percent moisture with subsequent favorable storage conditions was thought to be necessary for satisfactory storage.

404. SEMENIUK, G., NAGEL, C. M., and GILMAN, J. C. Observations on mold development and on deterioration in stored yellow dent corn. Iowa Agr. Expt. Sta. Res. Bul. 349, pp. 255-284. 1947.

Little or no fungus growth was found on corn at a relative humidity of 72.5 percent; only slight growth was found at 77.2 percent. A period of 50 to 72 days was required for fungi to appear at 72.5 percent relative humidity, and a period of 30 to 50 days at 77.2 percent.

405. SHARP, P. F. Wheat and flour studies. II. Aging I. The change in hydrogen-ion concentration of wheat and mill products with age. Cereal Chem. 1: 117-132. 1924.

Percent moistures from 4.8 to 14.8, at atmospheric temperature, room temperature (22° C.), or 35° C., had little effect on increasing acidity in normally ripened wheat, and caused only slight increase in acidity with frosted immature wheat.

406. SHULL, G. H. The longevity of submerged seeds. Plant World 17: 329-337. 1914.

After submergence for $4\frac{1}{2}$ years seeds of 11 species produced plants. Seeds of economic importance were not included.

407. SHUTT, F. T. (Dominion Chemist). Influence of age on wheat and flour. In Canada Expt. Farms Ann. Rpts., Rpt. Chemist, 1908-9: 144-147. 1909.

Wheat and flour stored for 16 months showed a slight increase in protein fractions attributable to a slow oxidation of carbohydrates.

408. SHUTT, F. T. (Dominion Chemist). Influence of age on wheat and flour. In Canada Expt. Farms Ann Rpts., Rpt. Chemist, 1910-11: 168-171. 1911.

A later report on the same observations given under reference number 407.

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*Arrhenatherum elatius (L.) Presl is the proper citation for tall oatgrass.

409. SIFTON, H. B. Longevity of the seeds of cereals, clovers and timothy. Amer. Jour. Bot. 7: 243-251. 1920.

Under extended seed storage, deterioration was observed to be gradual during the first 10 to 11 years, followed by 3 to 4 years when seeds of average viability died very rapidly, and a final period of 3 years in which the few remaining viable seeds died.

Losses in viability for the crops tested were as follows: Red clover, from 98 to 9 percent in 17 years; wheat, from 99 to 10 percent in 15 years; oats, from 95 to 40 percent in 18 years; timothy, from 97 to 10 percent in 12 years; and alsike clover, from 93 to 19 percent in 17 years.

410. SIMPSON, D. M. Relation of moisture content and method of storage to deterioration of stored cottonseed. Jour. Agr. Res. 50: 449-456. 1935.

Under favorable ventilated-storage conditions in Tennessee, cottonseed kept well for 2 years without preliminary drying. The viability of seed dried in the sun and stored under airtight conditions was kept high for 4½ years. The highest permissible moisture content for satisfactory storage was found to be 10 percent.

411. SIMPSON, D. M. Factors affecting the longevity of cottonseed. Jour. Agr. Res. 64: 407-419. 1942.

Cottonseed with 6 to 8 percent moisture, sealed in jars, kept well for 7 years at prevailing temperatures at Charleston, S. C., but was worthless after 2 years when the moisture content was 11 percent. When stored at 33° F., seed containing 14 percent moisture kept well for 3 years.

412. SIMPSON, D. M. The longevity of cottonseed as affected by climate and seed treatments. Amer. Soc. Agron. Jour. 38: 32-45. 1946.

With 10.8 percent moisture, cottonseed in storage deteriorated rapidly at Baton Rouge, La.; with 9.0 percent moisture, seed was viable after 5 years of storage in Tennessee. Some lots stored at Sacaton, Ariz., were viable after 25 years. Ceresan treatments prolonged viability.

413. SIMPSON, D. M. Cottonseed storage in various gases under controlled temperature and moisture. Tenn. Agr. Expt. Sta. Bul. 228, 16 pp. 1953. (In cooperation with U. S. Bur. Plant Indus., Soils, and Agr. Engin.)

Cottonseed with 7 percent moisture in sealed containers with air, oxygen, carbon dioxide, or nitrogen was maintained with no decline in germination for 10 years at 70° F.; at 90° no deterioration occurred in 3½ years. Seed containing 13 percent moisture had slightly over half of its initial germination at the end of 1 year of storage at 70°; at 90° only an occasional seed was viable after 6 months. No differential effect of gases was noted in the treatments.

414. SIMPSON, D. M. Longevity of cottonseed. Agron. Jour. 45: 391. 1953.

Cottonseed with a moisture content of less than 13 percent did not deteriorate in 15 years when stored at 33° F.; when the moisture was at 13 percent, full viability was retained for 13½ years. Seed with 7 percent moisture was highly viable at the end of 7½ years when stored at 70°. Deterioration was less rapid at a constant 70° than at fluctuating room temperatures. At 90° seed with 7 percent moisture had a storage limitation of 2 years.

415. SIMPSON, D. M., and MILLER, P. R. The relation of atmospheric humidity to moisture in cottonseed. Amer. Soc. Agron. Jour. 36: 957-959. 1944.

The moisture in cottonseed ranged from 3.5 percent at 10 percent relative humidity to 18.7 at 90 percent humidity.

416. SLATTER, E. M. The relation of temperature to seed germination--ii. The effect of temperature on stored seeds. North. Gard. [England] 4: 127-129. 1950.

Popular-type article pertaining to seed longevity, quoting Ohga's lotus seed experiment (see reference number 356), and the germination of 147-year-old seed of Albizzia julibrissin in London. Attention is called to Hevea brasiliensis seed; when packed so as to obtain a high concentration of CO_2, seed germinated 40 percent after 60 days as compared to 16 percent for seed commercially packed.

417. SNOW, D. Mould deterioration of stored feeding stuffs. Fert., Feed Stuffs and Farm Supplies Jour. [London] 30: 407, 409, 411-413. 1944.

In studying the moisture equilibrium of barley, oats, and corn, an increase of 1.2 percent moisture was found when the relative humidity was raised from 65 to 75 percent.

418. SONAVNE, K. M. Longevity of crop seeds, Part II. Agr. and Live-Stock in India 4: 287-292. 1934.

Naphthalene was not injurious when sealed with various seeds for 12 years. Legumes, with the exception of peanuts, had the best longevity. Sorghum, wheat, corn, pigeon pea, black gram, moth bean, and dolichos seeds were maintained at a germination of 60 percent or better over a period of 6 to more than 11 years. The drop in germination was gradual at first, followed by a period of rapid deterioration.

419. SORENSON, J. W., Jr., and DAVENPORT, M. G. Drying and storing flaxseed in Texas. Agr. Engin. 32: 379-382. 1951.

A moisture content of 6 to 7 percent was found to be the maximum for safe bin storage of flaxseed. Seed stored in sacks tolerated 7 to 9 percent.

420. SORENSON, J. W., and WILKES, L. H. Storage of cottonseed for planting purposes. Tex. Agr. Expt. Sta. Misc. Pub. 326, 8 pp. 1959.

Airflow cooling of cottonseed from 95° to 65° F. during a period of 50 to 120 hours maintained germination and prevented the development of free fatty acids.

421. SPENCER, G. E. L. Seed storage and germination. The use of cool storage in retaining the germinating power of some oil seeds. Trop. Agr. [Trinidad] 8: 333. 1931.

Soybeans held their original viability over a 10-month period at 50° to 60° F. but dropped from 96 to 11 percent germination when held at room temperatures (65° -87°). Results with peanuts were similar at 50° to 60° except that the drop in germination at room temperatures was only 15 percent.

422. STANSBURY, M. F., and GUTHRIE, J. D. Storage of cottonseed and peanuts under conditions which minimize changes in chemical composition. Jour. Agr. Res. 75: 49-61. 1947.

Very little chemical change was found in cottonseed in 2 years when it was stored at 1° C. or below. Peanuts with 5 percent moisture showed no appreciable change in 30 months when sealed and stored at 1°.

423. STEINBAUER, C. E., and STEINBAUER, G. P. Effects of temperature and desiccation during storage on germination of seeds of the American elm (*Ulmus americana* L.). Amer. Soc. Hort. Sci. Proc. (1931) 28: 441-443. 1932.

Elm seeds were sealed and stored over sulfuric acid at relative humidities of 85, 35, 5, and 1 percent at temperatures of 20°, 10° and 0° C. Others were sealed without a desiccant, and some were stored open to air. Under all temperatures except 20° a relative humidity of 1 percent appeared to be superior. The highest viability over 11 months of storage was at 0° and 1 percent relative humidity. With open storage at 20°, viability was lost in 7 months.

424. STEVENS, O. A. Germination studies on aged and injured seeds. Jour. Agr. Res. 51: 1093-1106. 1935.

During 20 years of laboratory storage in North Dakota the germination of alfalfa seed dropped from 97 to 65 percent, that of sweetclover from 97 to 60 percent. Sound seed kept better than injured or immature seed. Germination of soybeans dropped from 92 to 30 percent in 9 years, unhulled timothy from 98 to 52 percent in 11 years, and hulled timothy from 97 to 16 percent in 11 years.

425. STEVENSON, F. J., and EDMUNDSON, W. C. Storage of potato seeds. Amer. Potato Jour. 27: 408-411. 1950.

Potato seed stored at Beltsville, Md., in sealed containers at 34° F. maintained viability for 9 years. At Greeley, Colo., seed in sealed containers lost no viability when stored in a basement room, although germination was somewhat slower than with fresh seed.

426. STONE, E. C. Sugar pine [*Pinus lambertiana*] seedling survival; investigations indicate seed storage conditions important factor affecting vigor and subsequent survival of seedlings. Calif. Agr. 11 (9): 8, 15. 1957.

Survival of sugar pine seedlings grown from seeds stored at 36° F. for 2 years was 70 and 20 percent for freely watered and once-watered flats, respectively, as compared to a 90-percent survival of seedlings grown from fresh seeds for both watering treatments.

427. STRUVE, W. M. (Iowa State Col.) Drying and germinability of maize. (Abs. in Dissertation Abs. 19: 2222. 1959.)

Corn dried to various moisture contents was sealed in containers with various O_2 contents with N and stored at -30° to 50° C. When O_2 contents were 20 percent or above, deterioration was rapid, increasingly so as moisture rose from 0 to 11 percent. Seeds with 0 percent moisture stored at 50° in pure nitrogen were mostly dead at 31 months. Storage at low temperatures with moistures at 0 or 4 percent resulted in high viability.

428. SWAINE, G. Underground storage of maize in Tanganyika. East African Agr. Jour. 20: 122-128. 1954.

This paper reports the effect on insect infestation of storage in sealed underground concrete bins. No live insects were found after 379 and 446 days of storage.

429. SWANSON, A. F. Long-time storage of winter wheat. Amer. Soc. Agron. Jour. 31: 896-897. 1939.

Wheat with 11 to 12 percent moisture stored in ventilated 1,000-bushel bins at Clayton, Kans., had 53 percent germination at the end of 11 years.

430. SWANSON, C. O. Some factors involved in damage to wheat quality. Cereal Chem. 11: 173-199. 1934.

Germ damage was observed in wheat when molds were controlled by the exclusion of air, or by Ceresan, in 16 weeks of storage under laboratory conditions. High viability was maintained for 16 weeks in outdoor storage, either with or without Ceresan treatment, when under limiting air conditions or when sealed.

431. SWANSON, C. O. The effect of low temperature in preventing damage to wheat stored with high moisture content. Cereal Chem. 18: 299-315. 1941.

The critical moisture content for the preservation of wheat was 14 percent at laboratory temperatures, but at 41° F. viability was maintained with 20 percent moisture.

432. SWANSON, C. O., and FENTON, F. C. The quality of wheat affected by farm storage. Kans. Agr. Expt. Sta. Tech. Bul. 33, 70 pp. 1932.

As wheat advanced from the milk to the mature stage of ripening, the respiration of the grain decreased with advancing maturity and decreasing moisture content. A study of bin types and ventilation is included.

433. TAYLOR, C. A. Observations on the storage and germination characteristics of *Angelica* seed. Amer. Soc. Hort. Sci. Proc. 52: 471-474. 1948.

After 8 months' storage, seed of angelica herb germinated 88 percent when sealed and stored at room temperatures, and germinated 71 percent when stored unsealed. When sealed and stored at 35° C., germination was 47.5 percent.

434. TERVET, I. W. The influence of fungi on storage, on seed viability and seedling vigor of soybeans. Phytopathology 35: 3-15. 1945.

Mold infection of soybeans at room temperature increased with moisture content. Three molds, *Aspergillus flavus*, *A. niger*, and *A. ochraceus*, lowered germination. Treating with fungicides lowered mold infection.

435. THOMAS, R. C. The role of certain fungi in the "sick wheat" problem. Ohio Agr. Expt. Sta. Bimo. Bul. 22: 43-45. 1937.

Filtrates of 13 fungi cultures decreased germination of wheat. *Aspergillus flavus* was most detrimental. Wheat stored at 12.2 percent moisture and below 40° C. did not develop symptoms, but symptoms were general at 18.6 percent moisture and a temperature above 5°.

436. THOMPSON, H. J., and SHEDD, C. K. Equilibrium moisture and heat of vaporization of shelled corn and wheat. Agr. Engin. 35: 786-788. 1954.

A 7-percent rise in relative humidity resulted in an increase of 1 percent in the moisture content of corn. With no change in the absolute moisture in the air, a 50°-F. drop in temperature caused an increase of 2 percent in corn moisture.

437. THORNTON, N. C. Carbon dioxide storage. IX. Germination of lettuce seeds at high temperatures in both light and darkness. Boyce Thompson Inst. Contrib. 8: 25-40. 1936.

Germination tests of lettuce seed in the presence of carbon dioxide are reported rather than storage experiments. At 20° to 26° C. from 5 to 20 percent of CO_2 with 20 percent O_2 induced germination of lettuce in 17 hours.

438. THORNTON, N. C. Carbon dioxide storage. XII. Germination of seeds in the presence of carbon dioxide. Boyce Thompson Inst. Contrib. 13: 355-360. 1944.

Germination tests in the presence of carbon dioxide are reported rather than storage experiments. Higher concentrations of CO_2 than are found under average conditions of germination were necessary to inhibit the germination of seeds of buckwheat, cabbage, delphinium, onion, pepper, pea, radish, sunflower, tomato, and wheat.

439. TILLOTSON, C. R. Storage of coniferous tree seed. Jour. Agr. Res. 22: 479-510. 1921.

Seeds of various pine species stored at different locations in the United States for a 5-year period kept well only when stored in sealed containers. Storage at room temperature was found to be superior to fluctuating and to low or basement temperatures.

440. TOOLE, E. H. Storage of vegetable seeds. U. S. Dept. Agr. Leaflet 220, 8 pp. 1942.

Moisture equilibria for 18 vegetable seeds at relative humidities of 45, 65, 73, and 80 percent are given. The following storage conditions are recommended: Not over 70 percent relative humidity at 40° to 50° F.; one of 60 percent at 70°; and one of 45 percent at 80°.

441. TOOLE, E. H. Relation of seed processing and conditions during storage on seed germination. Internatl. Seed Testing Assoc. Proc. 16: 214-225. 1950.

A loss in viability and an increase in the number of slightly injured seedlings over a 36-week period were related to initial seed injury.

442. TOOLE, E. H. Report of Committee on Seed Moisture and Seed Storage. Internatl. Seed Testing Assoc. Proc. (1953) 18: [142]-145. 1954.

Procedures for moisture determinations are discussed, but experiments on storage are not considered.

443. TOOLE, E. H., and BROWN, E. Seed generally will not stand both high moisture and warmth. U. S. Dept. Agr. Yearbook 1934: 313-314. 1934.

General requirements for seed storage are given. Seed will survive with high moisture when stored at low, but above freezing, temperatures. Rapid deterioration results with high moisture contents and high temperatures, or fluctuation of either.

444. TOOLE, E. H., and BROWN E. Final results of the Duvel buried seed experiment. Jour. Agr. Res. 72: 201-210. 1946.

Seeds of 107 species of crop plants and weeds were buried in flowerpots in 1902. Final removal was made in 1941. Thirty-six species grew after being buried 39 years.

445. TOOLE, E. H. and DAVIDSON, W. A. The influence of storage conditions on the viability of soybean seed. Assoc. Off. Seed Anal. No. Amer. Proc. (1935) 27: 125-126. 1936.

Soybeans with 7.1 percent moisture retained their viability longer than those with 9.0 percent moisture. Varieties high in oil had a greater rate of deterioration than low-oil varieties.

446. TOOLE, E. H., and TOOLE, V. K. Relation of temperature and seed moisture to the viability of stored soybean seed. U.S. Dept. Agr. Cir. 753, 9 pp. 1946.

With 18 and 13 percent moisture, the viability of Mammoth Yellow and Otootan soybeans could not be maintained beyond 1 year of storage at 20° to 30° C.; with 13 percent moisture and a 10° storage temperature, viability was extended to 3 years. Reducing the moisture to 8.1 to 9.4 percent permitted storage for 10 years with high viability.

447. TOOLE, E. H., and TOOLE, V. K. Relation of storage conditions to germination and to abnormal seedlings of bean. Internatl. Seed Testing Assoc. Proc. (1953) 18: 123-129. 1954.

At 17° C. and 35 percent relative humidity beans retained their initial viability for 45 months; at 19° and 57 percent for 30 months; and at 21° and 57 percent for 27 months. Black Valentine proved to have a longer period of longevity than Brittle Wax.

448. TOOLE, E. H., and TOOLE, V. K. Viability of stored snap bean seed as affected by threshing and processing injury. U. S. Dept. Agr. Tech. Bul. 1213, 9 pp. 1960.

Snap beans under favorable open warehouse conditions or controlled storage deteriorated very little up to 45 months (maximum duration of tests) except for one open storage in one locality, where the temperature and humidity were high and the decline was rapid. For any particular variety, germination percentages fell less rapidly in lots with a high original percentage of perfect seedlings. Percentages of perfect seedlings decreased within the storage period, even for seed lots where the field emergence was unchanged.

449. TOOLE, E. H., TOOLE, V. K., and BORTHWICK, H. A. Bean storage and yielding ability. U. S. Agr. Res. Serv., Agr. Res. 5: 12. 1956.

Seeds of three bean varieties stored in Idaho for 4 years germinated promptly and used up reserves in the cotyledons in 10 to 14 days; whereas seeds under less favorable conditions in Texas produced slow-growing seedlings and used only one-fourth of the reserves.

450. TOOLE, E. H., TOOLE, V. K., and BORTHWICK, H. A. Growth and production of snap beans stored under favorable and unfavorable conditions. Internatl. Seed Testing Assoc. Proc. 22: 418-423. 1957.

After storage for 47 months (19° C. and 57 percent relative humidity) at Mercedes, Tex., and in a dry warehouse at Filer, Idaho, seeds of Plentiful, Black Valentine, and Brittle Wax were tested for germination and yielding potential. Germination of favorably stored seed averaged 23 percent better than that of the unfavorably stored. Yields per plant from favorably stored seeds averaged 21 grams higher than the yields from seed stored unfavorably.

451. TOOLE, E. H., TOOLE, V. K., and GORMAN, E. A. Vegetable-seed storage as affected by temperature and relative humidity. U. S. Dept. Agr. Tech. Bul. 972, 24 pp. 1948.

Moisture equilibria are given for 15 vegetable seeds at 3 temperatures and 8 relative humidities. After storage for 36 weeks most of the seeds tested were highly viable when stored at 70° F. and 65 percent relative humidity, also at 50° and 80 percent relative humidity. Bean, carrot, cucumber, pepper, and turnip seeds had high germination after 36 weeks of storage at 80° and 65 percent relative humidity.

452. TOOLE, E. H., TOOLE, V. K., and NELSON, E. G. Preservation of hemp and kenaf seed. U. S. Dept. Agr. Tech. Bul. 1215, 16 pp. 1960.

Viability of one lot of hemp seed, conditioned to moisture contents of 5.7 and 8.3 percent, was maintained for more than 8 years at 10° and -10° C. Seed with a moisture content of 5.7 percent did not decrease in germination in 6 years when stored in sealed jars at 21°. Two other lots with 9.5 percent moisture maintained full viability for 5½ years at -10° and 10°. Under controlled conditions at Lind, Wash., where the moisture content of the seed did not exceed 7.5 percent, the original viability of hemp seed was maintained 6 years.

Viability of kenaf seed, conditioned to a moisture content of 8 percent, was maintained for 5½ years when stored at 10°, 0°, and -10° C. With 12 percent moisture full viability was maintained for 5½ years at -10° and 0°, but the seed showed a significant loss in viability in 4 to 4½ years when stored at 10°.

453. TOOLE, E. H., TOOLE, V. K., and NELSON, E. G. Plastic bags for shipping seeds in the Tropics. Internatl. Seed Testing Assoc. Proc. 26: 86-88. 1961.

Kenaf seed in 10-mil polyethylene containers was maintained with no loss in germination for 15 months in Cuba. At the end of 27 months, germination dropped 35 percent. Five-mil polyethylene and laminated cellophane were not effective in maintaining germination under tropical conditions.

454. TOOLE, V. K., and TOOLE, E. H. Seed dormancy in relation to seed longevity. Internatl. Seed Testing Assoc. Proc. (1953) 18: 325-328. 1954.

Lettuce seed both initially dry and with imbibed moisture was stored 105 days at 30° C. and 85 percent relative humidity. Dry seed took up moisture after storage but, with the exception of one variety, was dead at 21 to 42 days. Imbibed seed germinated uniformly high after storage.

455. TOUMEY, J. W. Some notes on seed storage. Jour. Forestry 28: 394-395. 1930.

Seed of Sequoia gigantea with 62 percent germination had a germination capacity of 24 percent (actual germination 16 percent, the other sound) after 18 years 4 months of unsealed storage in the laboratory. The report recommends wet storage over the winter for bald cypress.

456. TOWERS, B., and HARRISON, G. J. Viability tests of cotton seed. Calif. Dept. Agr. Bul. 38: 25-31. 1949.

Acala cottonseed stored in metal containers for 10 years at Sacramento, Calif., dropped in germination from 84.0 to 22.9 percent; the drop in germination in burlap bags was to 30.4. Seed stored at Shafter, Calif., in burlap bags over the same period dropped to 15.2 percent germination.

457. TUITE, J. F., and CHRISTENSEN, C. M. Grain storage studies. XVI. Influence of storage conditions upon the fungus flora of barley seed. Cereal Chem. 32: 1-11. 1955.

Molds did not increase during storage when moisture contents of the grain were between 10 and 13 percent, but at 13.8 to 14.2 percent *Aspergillus* spp., which can reduce germination, invaded the embryos.

458. TURNER, J. H. The viability of seeds. Kew Roy. Bot. Gard., Bul. Misc. Inform. 1933: 257-269. 1933.

After 90 years' storage under room conditions *Anthyllis vulneraria* germinated 4.0 percent and *Trifolium striatum* 16.1. In 81 years T. *pratense* dropped to 2.6 percent, *Lotus uliginosus* (=*L. pedunculatus* Cav.) to 9.6, *Melilotus alba* to 0.61, and *Sarothamus scoparius* to 0.62. *Medicago sativa* had 22 percent germination after 78 years.

459. UEBERSEZIG, M. Successful storage of slash pine seed for fifteen years. Jour. Forestry 45: 825-826. 1947.

Slash-pine seed stored in a refrigerator with 9 to 10 percent moisture and temperatures between 35° and 38° F. had a germination of 88.66 percent after 15 years.

460. VAYSSIERE, P. Hermetic storage, the process of the future for the conservation of foodstuffs. *In* Preservation of grains in storage, F.A.O., U.N., Agr. Studies No. 2, pp. 115-122. 1948.

The accumulation of carbon dioxide in sealed storage was effective in the prevention of heating, fungal invasion, and insect infestation.

461. VENKATRAM, C. S. Seed-borne fungi and loss of cottonseed viability. Madras Univ. Jour. 19 (b): 79-112. 1950.

Cottonseed with 6 percent moisture stored at 28° to 30° C. was preserved better in sealed than in open containers. At these temperatures sealed containers caused fuzzy seed to lose viability more rapidly than acid-delinted seed, whereas the reverse was true for open storage. The tables and graphs of this report indicate that the highest degree of viability was maintained over a 15-week period with fuzzy seeds having a 9-percent moisture content and stored in open containers at 28° to 30°.

462. VIBAR, T., and RODRIGO, P. A. Storing farm crop seeds. Philippine Agr. Rev. 22: 135-146. 1929.

Rice lost all viability when stored 21 months in cloth bags under laboratory conditions. Except for the variety Australian, yellow dent corn had a shorter life span than rice. Soybeans dropped sharply in germination whether stored in bags or sealed. The loss of viability in shelled peanuts, sealed with or without naphthalene, was rapid after 1 year of storage; unshelled peanuts, however, held up for 2 years before a serious drop was encountered. Shelled peanuts were practically worthless after 8 months in cloth bags.

463. WAHLEN, F. T. Hardseededness and longevity in clover seeds. Internatl. Seed Testing Assoc. Proc. No. 9-10, pp. 34-40. 1929. [In English. German summary, pp. 39-40.]

Permeable seeds of red clover averaged 11.1 percent germination following 14 years of laboratory storage; impermeable seeds averaged 58.2 percent. Germination averages for alsike clover were 55 percent for permeable seeds, 79.2 percent for impermeable ones.

464. WAKELEY, P. C. Successful storage of longleaf pine seed. U. S. Forest Serv., Forest Worker 7 (1): 10. 1931. (Also Jour. Forestry 29: 424-425. 1931.)

Seed of longleaf pine, sealed and stored at 25° to 30° F., dropped from 85 to 82 percent germination in 2 years.

465. WALLEN, V. R. The effect of storage for several years on the viability of Ascochyta pisi Lib. in pea seed and on the germination of the seed and emergence. U. S. Agr. Res. Serv. Crops Res. Div., Plant Dis. Reporter 39: 674-677. 1955.

Eighteen varieties of pea were stored at 50° to 70° F. and 70 percent relative humidity for periods of from 2 to 13 years. Little loss in germination occurred, and infections caused by Ascochyta pisi Lib. were largely eliminated after storage for 7 years.

466. WARD, H. S., Jr. The effect of various moistures in the Dixie Runner peanut on free fatty acids, germination, and respiration during storage. South. Agr. Workers Assoc. Proc. 1953: 170-171. 1953.

Peanuts with 7 percent moisture were held 7 months at 35° C. without an increase in free fatty acids. To maintain 80 percent germination with storage at 35°, a moisture content of 6.0 percent was required. Germinations from 0 to 20 percent resulted in 5 weeks when the nuts were stored at 30° with 7.0 percent moisture.

467. WARK, D. C. The influence of storage in contact with certain seed-pickling dusts on the germination of grain. Austral. Inst. Agr. Sci. Jour. 8: 22-25. 1942.

Wheat was treated with 9 dusts and stored for 8 weeks at temperatures from 0° to 30° C. Germination was increased through use of the majority of the dusts except those containing ethyl mercury phosphate stored at 20°. Seven dusts were used on barley and the seed stored for 12 weeks. Germination was not affected by the dusts in conjunction with 10°, 20°, and 30° storage temperatures.

468. WARNER, M. G. R., and LAWTON, P. J. The use of polyethylene film bags for grain samples. Natl. Inst. Agr. Engin. [Silsoe, England] Rpt. 34, 7 pp. [1953].

Polyethylene bags 0.005 inch thick were effective in maintaining moisture in grain, with little change over a period of a week or longer, under normal atmospheric conditions. [From Herb. Abs. v. 25, No. 1137. 1955.]

469. WEIBULL, G. The cold storage of vegetable seed and its significance for plant breeding and the seed trade. Agri Hortique Genetica 10: [97]-104. 1952. [Paper presented to the 13th Internatl. Hort. Cong., London, 1953.]

When stored at -20° C., onion and chive seeds germinated well after 4 years; parsnip, red beet, celeriac, and carrot after 2 years. The initial and final germinations for these were: Onion 93 and 92 percent; chive 85 and 77, 89 and 95; parsnip 96.5 and

96; beet 91 and 89; celeriac 86 and 84; and carrot 84 and 83, 89 and 82. Of a number of ornamental seeds tested, Delphinium ajacis, Verbena venosa, Viola tricolor maxima, and Asparagus plumosus were preserved better at 0° than at -20°. Storage conditions were 85 to 95 percent relative humidity at 0° and -20°, and 70 to 80 percent relative humidity at 5° to 20°.

470. WEIBULL, G. The cold storage of vegetable seed--Further studies. Agri Hortique Genetica 13: 121-142. 1955.

This paper covers an additional 3 years of the work reported in the above reference. The final results are given under the following reference.

471. WEIBULL, G. The cold storage of vegetable seed, further studies. Internatl. Hort. Cong. Rpt., The Hague-Scheveningen (1955), 14: 647-667. [1956.]

For maintenance of viability over a 7-year period, storage of onion, chive, celeriac, carrot, beet, and parsnip seeds proved superior at -20° C. to their storage at 0° or at ordinary storage of 5° to 20°. Subsequent to the -20° period, storage for an extra year at 11° did not impair germination, whereas some loss was involved after an extra year at 0° storage. Beet seed was affected less by storage temperatures than the other seeds. Parsley seed was adversely affected by -20° storage, but 0° storage was favorable. Storage temperatures for 15 flower species are also given.

472. WEISS, M. G., and WENTZ, J. B. Effect of luteus genes on longevity of seed in maize. Amer. Soc. Agron. Jour. 29: 63-75. 1937.

Luteus$_2$ and luteus$_4$ genes in maize were associated with low vigor and short life. A linkage between the luteus genes and others affecting vitality was postulated.

473. WELTON, F. A. Longevity of seeds. Ohio Agr. Expt. Sta. Monthly Bul. 6: 18-25. 1921.

Moist seeds of 28 crops stored in stoppered bottles at room temperatures kept well for 3 to 4 years; alsike and mammoth clover held up for 10 years; alfalfa and trefoil, 9 years; and field peas, 8 years.

474. WENT, F. W., and MUNZ, P. A. A long term test of seed longevity. El Aliso 2: 63-75. 1949.

One hundred noncrop seed species were subjected to extreme desiccation and stored in vacuum at 10° to 20° C. Desiccation alone had no effect on germination, but at the end of the first year of storage an average drop of 10 percent in viability was noted.

475. WEST AFRICAN RICE RESEARCH STATION. Dormancy and viability of rice seed. West African Rice Res. Sta. [Rokupr, Sierra Leone], Ann. Rpt. 1956: 27-28. 1958.

Rice of four varieties stored sealed with 11 percent moisture at ambient temperatures or unsealed with 15 percent moisture at 8° C. maintained 100 percent of viability for 1 year, as compared to 50 percent for controls under normal storage. Storage at 8° extended the dormancy period of one variety at least 15 months.

476. WESTAWAY, S. J. Sexual and asexual propagation of Euonymus. West Canad. Soc. Hort. Rpt. Proc. 30: 65-66. 1957.

This paper is not a report of research work, but attention is called to the probability that seed of euonymus may be preserved in dry storage for 2 years or longer in sealed containers at 41° F.

477. WESTON, T. A. Longevity of seeds. Gard. Chron. (ser. 3) 92: 323-324. 1932.

This article is of a popular nature relating to the immediacy of germination and dormancy. Longevity per se is not discussed.

478. WESTON, W. J., and MORRIS, H. J. Hygroscopic equilibria of dry beans. Food Technol. 8: 353-355. 1954.

Moisture equilibria of beans at 25° C. ranged from approximately 6 percent at 11 percent relative humidity to 16.6 percent at 75.3 percent humidity. The time required to reach equilibria was greater at the two extremes of relative humidity.

479. WHITE, D. G. Longevity of bamboo seed under different storage conditions. Trop. Agr. [Trinidad] 24: 51-53. 1947.

When sealed and stored over $CaCl_2$ the initial germination of a seed crop of Bambusa arundinacea was maintained for 202 days at temperatures of 70° to 90° F., 60° to 70°, and 50°. Initial germination of the following year's seed crop was maintained for 227 days when the seed was stored over $CaCl_2$ at either 70° to 90° or 44° to 50°, also at 44° to 50° when charcoal was used as a desiccating agent.

480. WHITE, J. The ferments and latent life of resting seeds. Roy. Soc. London, Proc., Ser. B., 81: 417-442. 1909.

No difference was found in the enzyme content of fresh and old seeds even though the old were nonviable. Seeds of wheat, barley, oats, rye, and corn were subjected to temperature extremes of -200° and 120° C. without destroying enzymes or impairing germination. Seeds of apple, hemp, lobelia, parsnip, and parsley were injured by a -200° temperature, whereas those of cress, carrot, mustard, pea, radish, castorbean, and sunflower were unharmed.

481. WHITEHEAD, E. I., and GASTLER, G. F. Hygroscopic moisture of grain sorghum and wheat as influenced by temperature and humidity. S. Dak. Acad. Sci. Proc. 25: 80-84. 1945.

Moisture contents of wheat and sorghum at the same relative humidities were higher at 1° C. than at 20°. At 60 percent relative humidity the moisture percentages of wheat were 15.62 at 1° and 15.27 at 20°. The corresponding moistures of sorghum were 17.22 and 15.51, respectively.

482. WHITTET, J. N. Giant panic grass seed retains its viability. Agr. Gaz. N. S. Wales 54: 494. 1943.

This reference is a short note to the effect that seed of Panicum antidotale retains its viability for 4 years under climatic conditions prevailing in Trangie.

483. WHYMPER, R., and BRADLEY, A. Studies on the vitality of wheat. I. Prolongation of the vitality of wheat seeds. Cereal Chem. 11: 349-360. 1934.

Wheat with moisture reduced to 0.66 percent germinated 82 percent after storage for 15 years 9 months. Another variety with 4.38 percent moisture germinated 83 percent after 18 years 11 months. Complete inhibition of respiration was thought to be destructive to vitality and limited respiration beneficial.

484. WILLIAMS, M. The moisture content of grass seed in relation to drying and storing. Welsh Jour. Agr. 14: 213-232. 1938.

Ryegrass had a moisture equilibria of 14.0 percent at 60° F. and 80 percent relative humidity; corresponding equilibria for timothy and cocksfoot were, respectively, 13.6 and 13.0. Drying seeds of grasses above 104° to 110° was injurious. Under atmospheric conditions, seeds of high purity equilibrated at a lower moisture content than those of low purity.

485. WILSON, J. K. Acidity changes in stored legume seeds. Amer. Soc. Agron. Jour. 2: 815-817. 1929.

Acidity studies made of various legume seeds, including those that are usually inoculated with artificial cultures, showed that of seeds ranging from fresh to 10 years in age the older ones usually had a more acid reaction. It is believed that this change in reaction may have some bearing not only on the longevity of legume bacteria naturally carried by seeds but also on the longevity of bacteria artificially added.

486. WINCHESTER, W. J. Storing seed of green panic and buffel grass for better germination. Queensland Agr. Jour. 79: 203-204. 1954.

Panicum maximum var. trichoglume (green panic grass), which at harvest germinated 11 percent when hand stripped and 3 percent when heaped and flailed, increased in germination capacity to 46 percent for the hand stripped after 25 months and to 18 percent for the heaped and flailed after 18 months. Hand stripped buffel grass, which had an initial germination of 3 percent, had 79 percent after 13 months and 44 percent after 60 months. Original germination when the heads were cut and dried was 11 percent, followed by an increase to 52 percent in 16 months and a drop to 21 percent in 60 months. When buffel grass was mowed and dried in the field the germination rose from 32 to 43 percent in 19 months followed by a drop to 30 percent in 60 months.

487. WINTERS, H. F., and RODRIGUEZ-COLON, F. Storage of mangosteen seed. Amer. Soc. Hort. Sci. Proc. 61: 304-306. 1953.

With only 10 seeds used per test, none germinated when stored at 50° F., regardless of treatment. When stored at 70° to 85° the best results (germination 82.5 percent in 7 weeks) were with storage in charcoal dust with 42.5 percent moisture. In peat moss with 39.4 percent moisture, germinability was preserved for 6 weeks. Storage in the fruit, or when the seeds were in dry storage, resulted in loss of viability.

488. WORK, P. Longevity of sweet corn and onion seed. Market Growers Jour. 69: 388-389. 1941.

In 1941 germination tests were run on four varieties of sweet corn received at Cornell University since 1929, and on four varieties of onion received since 1937. Except for Extra Early Bantam, all sweet corn varieties had lost viability in 12 years and some in 7 years. All onion varieties except Brigham Yellow Globe lost viability in 5 years.

489. YOUNGMAN, B. J. Germination of old seeds. Kew Roy. Bot. Gard., Kew Bul. 1951: 423-426. 1952.

The article is mostly a review of work on longevity reported by other authors (reference numbers 126, 127, 148, 150, 161, 356, 444, 458). Of 300 seeds each of Trifolium pratense and Lotus uliginosus (=L. pedunculatus Cav.), both lots from plant specimens 100 years old, only 1 seed germinated.

490. ZELENY, L. Fat acidity in relation to heating of corn in storage. Cereal Chem. 17: 29-37. 1940.

The rate of heating in corn rose rapidly at 18 percent moisture or above, and an increase in fat acidity was in direct proportion to the incidence of heating.

491. ZELENY, L., and COLEMAN, D. A. The chemical determination of soundness in corn. U. S. Dept. Agr. Tech. Bul. 644, 24 pp. 1939.

An increase in fat acidity was found to be the major cause of deterioration in corn. Formulas are given for the calculation of total acidity in the grain.

492. [ZIMMER. E.] How long do seeds retain their vitality? Nature [London] 132: 469-470. 1933.

This article is popular in scope and shows the fallacy of supposed germination of "mummy" wheats.

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